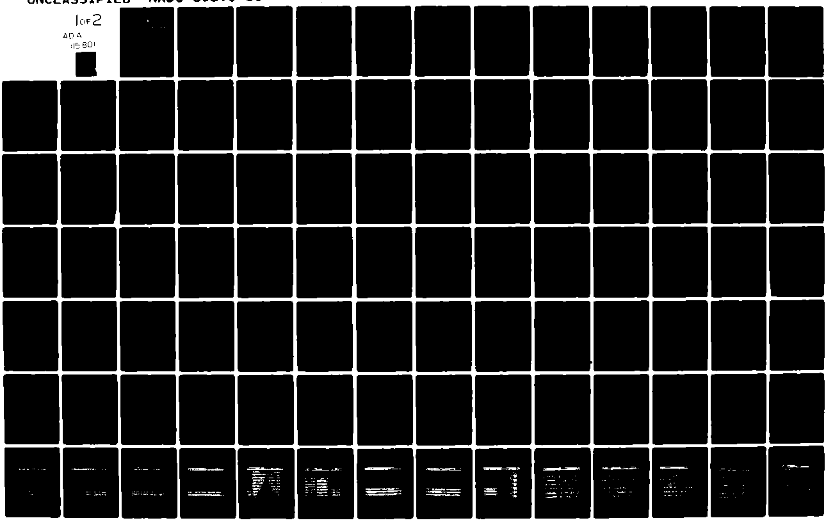
AD-A115 801 NAVAL AIR DEVELOPMENT CENTER WARMINSTER PA AIRCRAFT --ETC F/G 14/2
USER'S GUIDE FOR THE ROTORCRAFT FLIGHT SIMULATION COMPUTER PROG--ETC(U)
MAR 82 B J GAJKOWSKI
UNCLASSIFIED NADC-81290-60 NL

1 OF 2
AD A
115 801



(12)

REPORT NO. NADC-81290-60

USER'S GUIDE FOR THE ROTORCRAFT FLIGHT SIMULATION COMPUTER PROGRAM C81, AGAP80 VERSION, CDC CONVERSION

B. J. Gajkowski
Aircraft and Crew Systems Technology Directorate
NAVAL AIR DEVELOPMENT CENTER
Warminster, Pennsylvania 18974

MARCH 1982

FINAL REPORT
AIRTASK NO. A03V-0000/001B/2F41-400-000

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

Prepared for
NAVAL AIR SYSTEMS COMMAND
Department of the Navy
Washington, D. C. 20361

N O T I C E S

REPORT NUMBERING SYSTEM - The numbering of technical project reports issued by the Naval Air Development Center is arranged for specific identification purposes. Each number consists of the Center acronym, the calendar year in which the number was assigned, the sequence number of the report within the specific calendar year, and the official 2-digit correspondence code of the Command Office or the Functional Directorate responsible for the report. For example: Report No. NADC-78015-20 indicates the fifteenth Center report for the year 1978, and prepared by the Systems Directorate. The numerical codes are as follows:

CODE	OFFICE OR DIRECTORATE
00	Commander, Naval Air Development Center
01	Technical Director, Naval Air Development Center
02	Comptroller
10	Directorate Command Projects
20	Systems Directorate
30	Sensors & Avionics Technology Directorate
40	Communication & Navigation Technology Directorate
50	Software Computer Directorate
60	Aircraft & Crew Systems Technology Directorate
70	Planning Assessment Resources
80	Engineering Support Group

PRODUCT ENDORSEMENT - The discussion or instructions concerning commercial products herein do not constitute an endorsement by the Government nor do they convey or imply the license or right to use such products.

APPROVED BY: JRWoods DATE: 4/5/82

J. R. WOODS
CDR USN

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NADC-81290-60	2. GOVT ACCESSION NO.: AD-A115 801
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): USER'S GUIDE FOR THE ROTORCRAFT FLIGHT SIMULATION COMPUTER PROGRAM C81, AGAP80 VERSION, CDC CONVERSION	5. TYPE OF REPORT & PERIOD COVERED: FINAL
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): B. J. GAJKOWSKI	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Aircraft & Crew Systems Technology Directorate, Naval Air Development Center, Warminster, PA 18974	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: P.E. 62241N, Task Area WF41-423-000, AIRTASK #A03V-0000/001B/2F41-400-000
11. CONTROLLING OFFICE NAME AND ADDRESS: Naval Air Systems Command, Department of the Navy, Washington, DC 20361	12. REPORT DATE: March 1982
	13. NUMBER OF PAGES: 98
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

C81
AGAP80 Version
Flight Simulation
Stability Analysis
Helicopters
Rotorcraft
Flight Dynamics
CDC Conversion

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The current version of the Rotorcraft Flight Simulation Program C81, AGAP80, was installed in a CDC converted form on the CDC CYBER 175/CDC 6600 Computer System at NAVAIRDEVCEN. The problems encountered in validating this CDC conversion, using the TR-80-D-38A User's Manual sample case as a test case, are described. The program capabilities in the area of Flight Dynamics analysis are repeated as a quick guide to the user in order to maintain continuity with the USAAVRADCOM-TR-80-D-38A User's Manual. This report is

(continued on other side)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

not meant to supercede TR-80-D-38A. An effort is made throughout the description of the program capabilities to provide the user with a description of the inputs required to perform that particular program operation and the output data that resulted. The user is referred to the TR-80-D-38A User's Manual for the information necessary for assembling a complete input data deck and to successfully execute the program. There were two program operation problems identified while running test cases on this CDC conversion of the AGAP80 version. These two were the inability to perform any of the postprocessing operations of GDAP80 and the inability to compute eigenvalues in the rotorcraft stability analysis. The cost of running this program at NAVAIRDEVCEN to perform a trimmed flight analysis, a rotorcraft stability analysis, and a maneuver simulation is discussed.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF TABLES

INTRODUCTION

The purpose of this document is to provide an abbreviated user's guide for the current version of the Rotocraft Flight Simulation Program C81 as installed at NAVAIRDEVCEN. This document is to be used as a quick guide to the program capabilities of C81 in the area of Flight Dynamics analysis. It also describes the problems encountered with the current version of the program, designated AGAP80, as delivered to this Center. It should be noted that the problems that are described herein are associated with the copy of the CDC converted program that is installed on the CDC CYBER 175/CDC 6600 Computer System at NAVAIRDEVCEN and are not considered universal.

The Rotorcraft Flight Simulation Program C81 has been developed and under continual update/revision since the early 1960's by Bell Helicopter Textron under contract with the Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM), Ft. Eustis, VA. All versions of the program have been developed for usage on an IBM computer system. Early in 1980 the Naval Air Development Center and the NASA Langley Research Center expressed interest in a CDC conversion of the program for their CDC CYBER computer systems. A successful conversion of the program was completed in June, 1980 by Mr. Robert Tomaine of the Army Structures Laboratory and a magnetic tape of the program source was delivered to NAVAIRDEVCEN in July, 1980.

This conversion was done to the most current version of the computer program and is referred to as AGAP80.

After many installation problems were overcome, the program was installed on the CDC CYBER 175/CDC 6600 Computer System at NAVAIRDEVCEN in March, 1981. The period from March through September, 1981 was devoted to validation of the CDC conversion on NAVAIRDEVCEN's computer system and understanding of the program capabilities and applications.

A complete input data deck for an AH-1G helicopter was provided with the source tape as a sample case for validating the program at NAVAIRDEVCEN. This AH-1G data deck is used throughout this report to illustrate the program capabilities.

An effort is made throughout the description of the program capabilities to provide the user with a description of the inputs required to perform that particular program operation and the output data that resulted. The user is referred to the user's manual for the AGAP80 version (reference 1) for the information necessary for assembling a complete input data deck and to successfully execute the program.

Two program operation problems were identified while running test cases to check out each of the program operational capabilities. These two were the inability to perform any of the postprocessing operations of GDAP80 and the inability to compute the rotorcraft characteristic equation roots and associated transfer functions in the rotorcraft stability analysis. Both of these problems are associated with the copy of the AGAP80 version that is installed at NAVAIRDEVCEN and are not universal problems with this program. The cause of the postprocessing problem has been identified and is relatively easy to fix, while the eigenvalue calculation problem is still under investigation.

This program provides the capability to analytically examine the flying qualities characteristics of a given model of helicopter, whether it be single, tandem, or tilt rotor. The input data can be minimal for a rough first-cut examination of a preliminary design, or extensive for a simulation of an existing aircraft for which fuselage aerodynamic, airfoil, aeroelastic blade, and rotor induced velocity distribution data are already known through previous testing.

This program can perform a trimmed flight analysis, a rotorcraft stability analysis, parameter sweeps of trimmed flight conditions, and a maneuver simulation. It also can retrieve maneuver time-history data stored on magnetic tape, print plots of time-history data, and store maneuver time-history data on tape. The program has other postprocessing capabilities which are performed on time-history data which would be of interest to structural analysis engineers. All of these operational capabilities are discussed in this report.

PROGRAM CAPABILITIES

AGAP80 OPERATIONS

The AGAP80 version of the C81 program is capable of performing the following general operations:

1) Compute a trimmed flight condition

2) Perform a rotorcraft stability analysis

3) Perform parameter sweeps of trim conditions, with or without a rotorcraft stability analysis

4) Compute a maneuver with or without a rotorcraft stability analysis

5) Retrieve maneuver time-history data stored on magnetic tape

These five operations are illustrated in the flow charts given in figures 1 through 8. The block labelled "OPERATIONS ON TIME-HISTORY DATA" represent the execution of the postprocessing program, GDAP80.

Each of the AGAP80 operations or combination of operations is controlled by input data. Since the amount of data to be read depends on the operation or operations desired, a data deck in this context consists of a message card, an "NPART" card telling the program which primary operation or operations to perform, and the additional data necessary to perform the indicated operations. In some cases the additional data are contained on 500 or more additional cards, while in other cases, as little as a few cards of additional data is required for the AGAP80 input deck.

The second step in several of the flow charts is "CALCULATE PROBLEM CONSTANTS." In each operation containing this step, a number of quantities which remain constant throughout the performance of the operations must be defined using the input data. Performing such computations drastically reduces the number of program inputs and also provides program flexibility necessary for incorporating such operations as parameter sweeping.

TRIMMED FLIGHT

In finding the trim point, the program iterates on the control positions, fuselage orientation, rotor attitude and/or engine power to reach desired values of the rotor flapping moments, forces and moments on the aircraft center of gravity and/or engine horsepower. When these desired values are achieved the rotorcraft is trimmed.

The program also permits the calculation of two steady but accelerated flight conditions. In one, the rotorcraft is in a pushover or pullup condition at an input g-level. In the other, the rotorcraft is in a banked turn, either level or spiral, at an input g-level. In these cases, the desired net forces and moments on the rotorcraft are not all zero, but depend on the user-requested g-level. Either an unaccelerated or steady accelerated flight condition may be used as the starting point of a maneuver simulation.

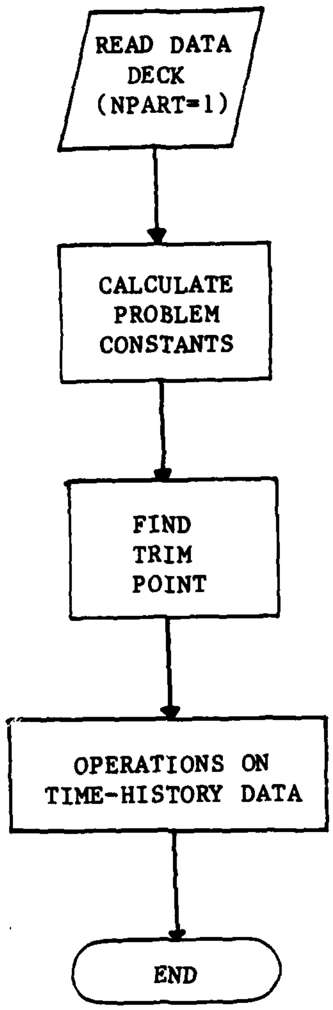


Figure 1. Trim-Only Operation.

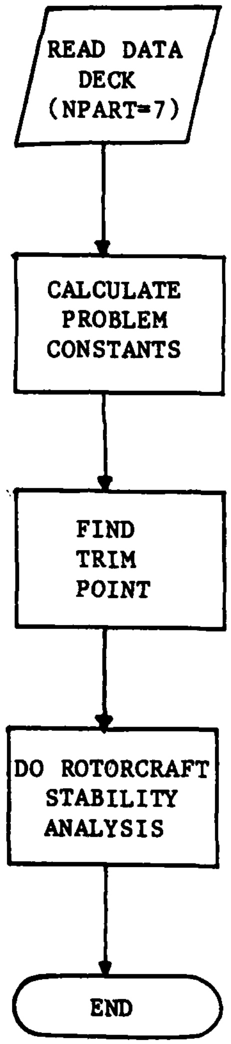


Figure 2. Trim and Rotorcraft Stability Analysis.

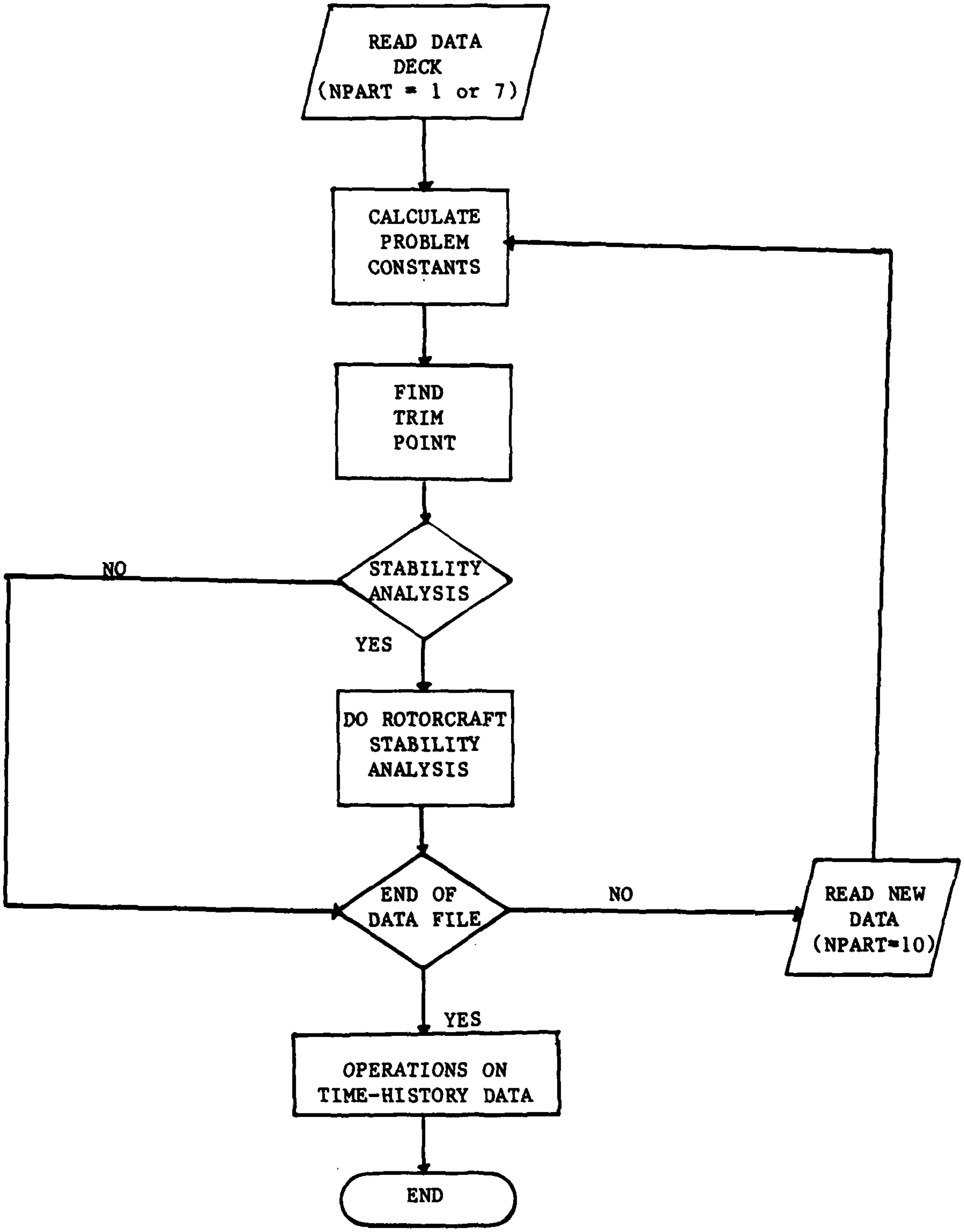


Figure 3. Trim or Trim and Rotorcraft Stability Analysis Followed by Parameter Sweep.

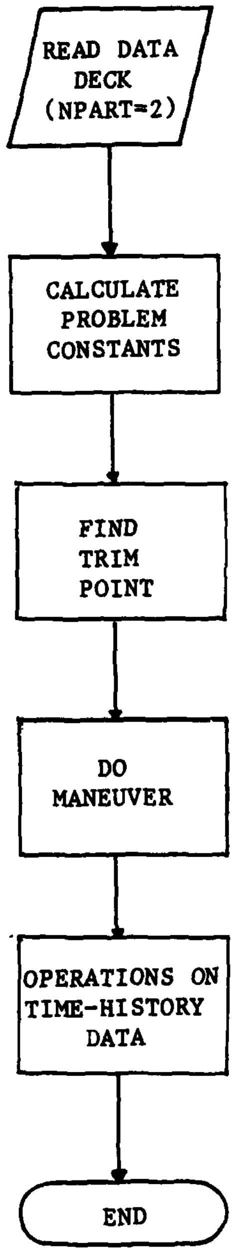


Figure 4. Trim Followed by Maneuver.

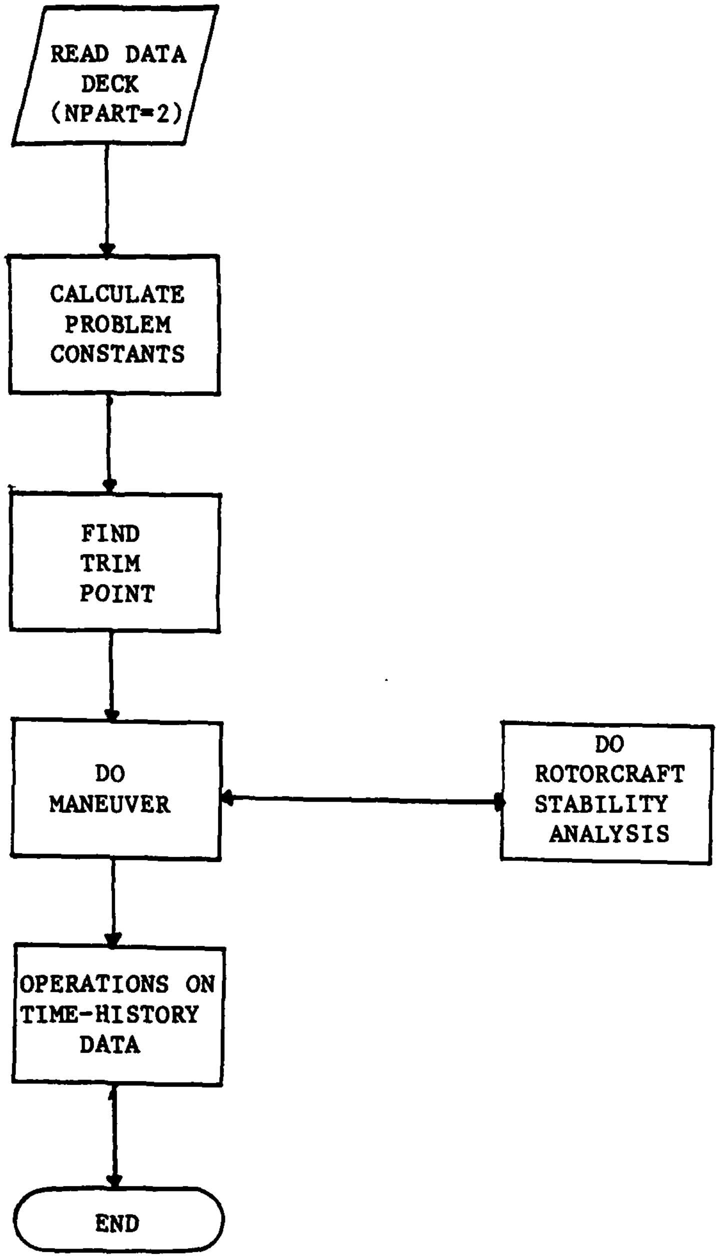


Figure 5. Trim Followed by Maneuver with Rotorcraft Stability Analysis.

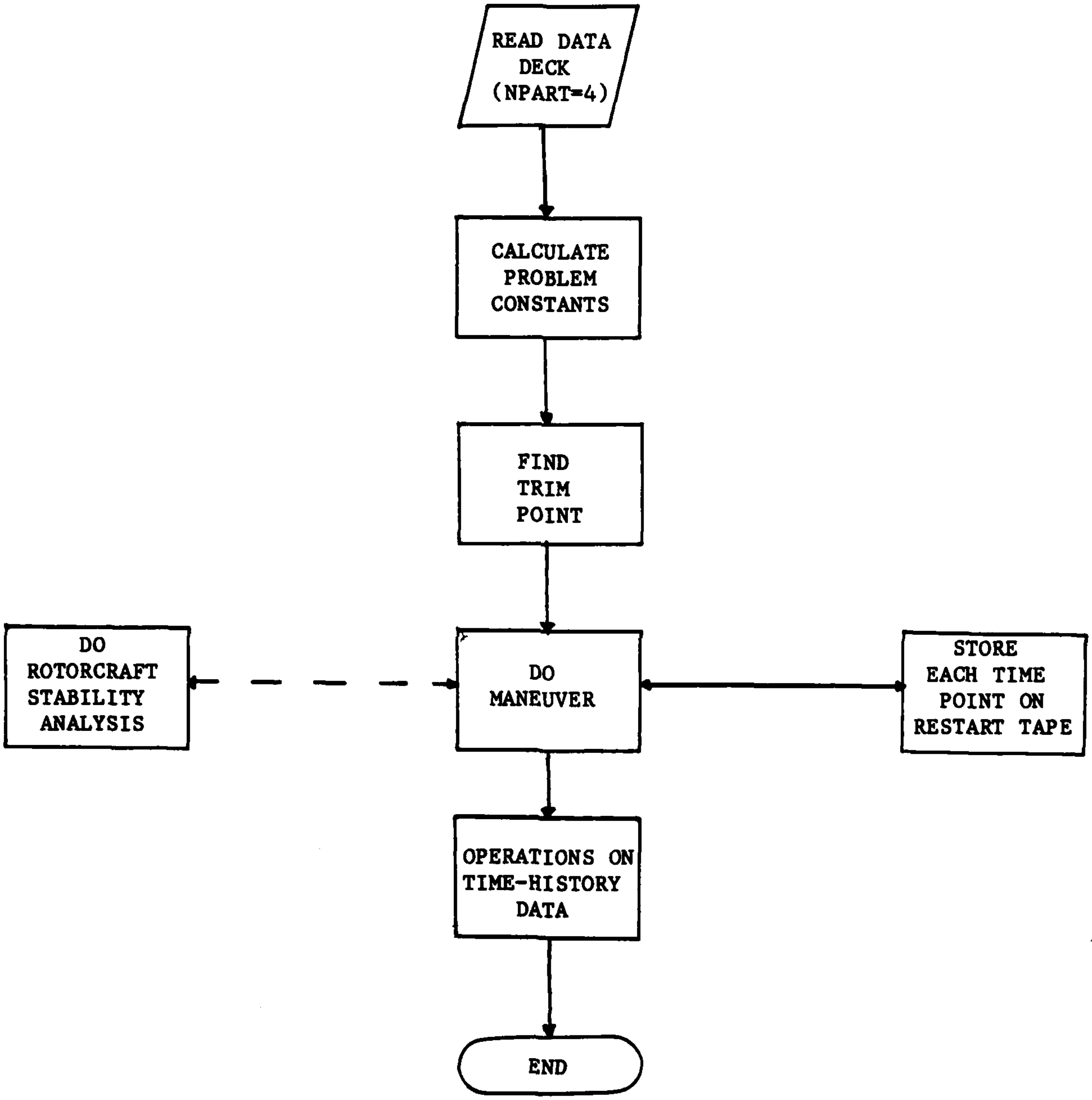


Figure 6. First Maneuver in Restart Procedure.

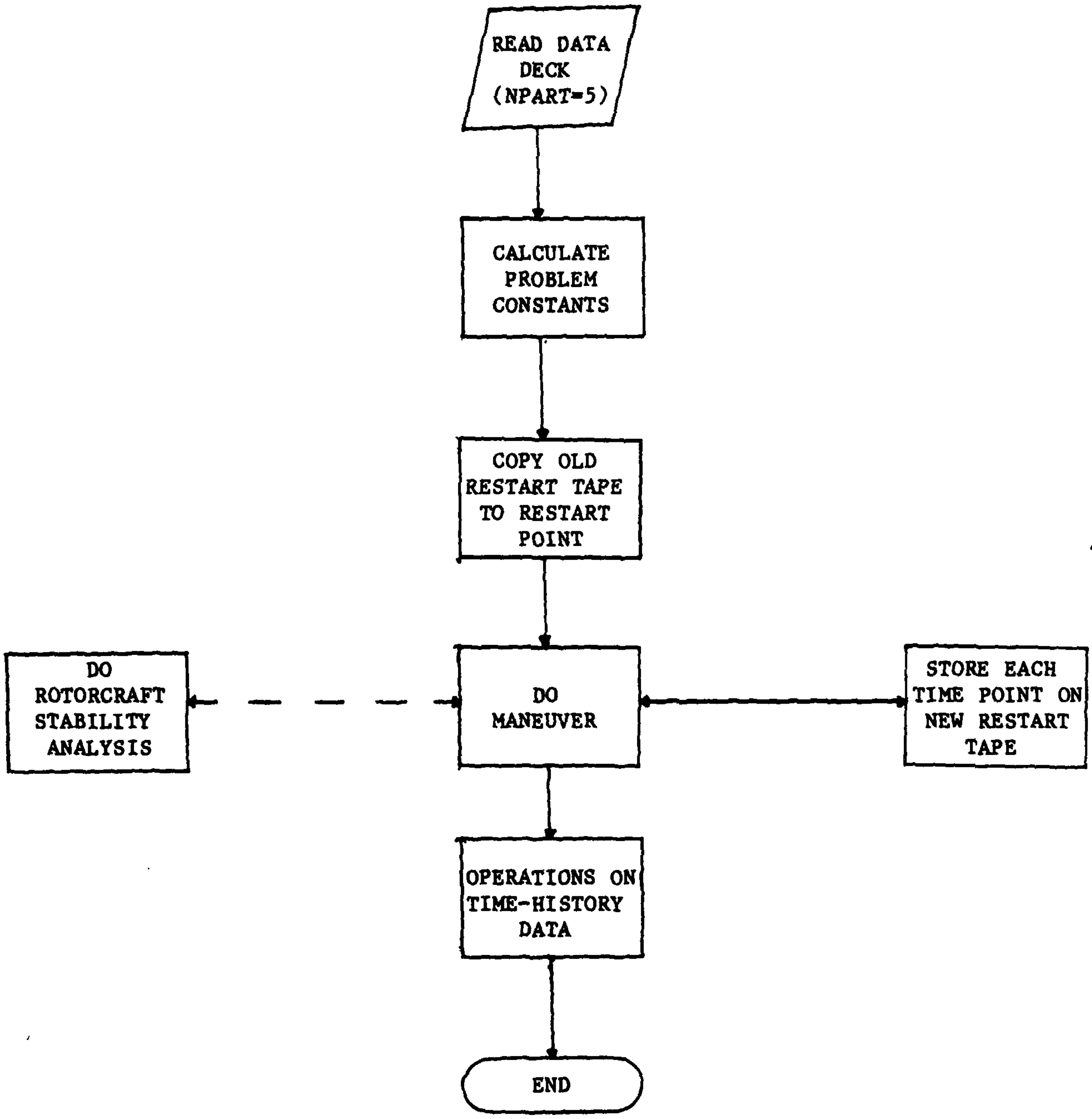


Figure 7. Second and Later Restart Maneuvers.

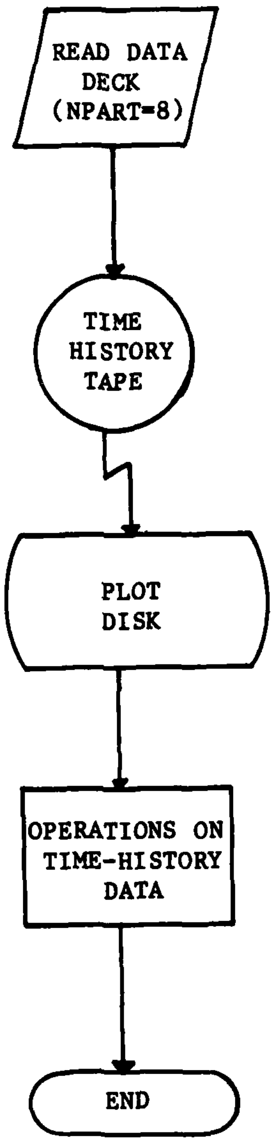


Figure 8. Retrieving Maneuver Data Stored Permanently.

A complete input data deck for AGAP80 can be divided into the 53 groups or sets of cards listed in table I. The first 45 groups form the basic card deck, which is used for trim-only and trim-and-rotorcraft-stability-analysis-only program operations. The remaining eight groups are only included in the deck when a maneuver is to be simulated.

A sample input data deck for a trim followed by maneuver is presented in Appendix A. Some of the more significant inputs will be discussed here, but for a more detailed explanation of all the inputs see reference 1. In discussing the input data, attention will be directed to the card numbers printed in columns 73-80.

NPART Card

In order to compute a trimmed flight condition the NPART card (card 002) requires a "1" in column 1-2. This card includes the primary program control variable, NPART. Permissible values of NPART on this card are 1,2,4,5,7, and 8. The value of NPART specifies the type of operation to be performed.

1 = Trim only
2 = Trim followed by maneuver (maneuver not to be restarted)
4 = Trim followed by maneuver (maneuver to be restarted)
5 = Maneuver restart
7 = Trim followed by rotorcraft stability analysis
8 = Retrieve maneuver data from tape for analysis

Program Logic Group

The Program Logic Group (cards 006-013) is one of the most important groups in the deck because it contains the bulk of the program logic controls. It controls which groups must be included in the deck and the program options that will be used in the computations. This group consists of seven cards with 14 integer inputs per card. Each element of the IPL array is identified as IPL(1-98). Sections 2.3 and 4.3 of reference 1 describe in brief and in detail respectively all of the program logic inputs. The logic inputs control the three phases of the C81 program:

1) Input group control logic - controls the data groups which must be included in the input data.
2) Analysis logic - controls the program options to be used such as unsteady aerodynamics, time-variant rotor analysis, etc.
3) Output control logic - controls the data to be output.

The logic has been chosen so that for the simplest cases most inputs are zero. In general, nonzero inputs activate the options and/or necessitate inputs of additional data.

Quasi-Static vs. Time-Variant Trim Analysis

IPL (49) and (50) are the program logic inputs that control the type of trim analysis performed. AGAP80 includes three types of trim procedure:

1) Quasi-Static (QS) Trim
2) Quasi-Static followed by Time-Variant Rotor (QS-TV) Trim
3) Fully Time-Variant (FTV) Trim

TABLE I SEQUENTIAL SUMMARY OF INPUT GROUPS

GROUP TITLE	AGAP80 SEQUENCE NUMBER OF ID CARD *	AGAP80 SEQUENCE INPUT CARD NUMBERS **	REFERENCE CARD SEQUENCE NUMBER ****
Deck Identification & Program Flow Control Cards	None	00 - 04	001 - 005
Program Logic Group	10	10 - 17	006 - 013
Airfoil Data Table Group			
Airfoil Data Table Set No. 1	21	21/A,/B1,/C1,/D1	014 - 295
Airfoil Data Table Set No. 2	22	22/A,/B1,/C1,/D1	296 - 506
Airfoil Data Table Set No. 3	23	23/A,/B1,/C1,/D1	N/A
Airfoil Data Table Set No. 4	24	24/A,/B1,/C1,/D1	N/A
Airfoil Data Table Set No. 5	25	25/A,/B1,/C1,/D1	N/A
Airfoil Data Table Set No. 6	26	26/A,/B1,/C1,/D1	N/A
Airfoil Data Table Set No. 7	27	27/A,/B1,/C1,/D1	N/A
Airfoil Data Table Set No. 8	28	28/A,/B1,/C1,/D1	N/A
Airfoil Data Table Set No. 9	29	29/A,/B1,/C1,/D1	N/A
Airfoil Data Table Set No. 10	2A	2A/A,/B1,/C1,/D1	N/A
Rotor 1 Group	30	30 - 3P	507 - 524
Rotor 1 Elastic Pylon Group	40	40 - 4V	N/A
Rotor 1 Elastic Blade Data Group	50	50 - 5C	525 - 765
Rotor 2 Group	60	60 - 6P	766 - 774
Rotor 2 Elastic Pylon Group	70	70 - 7K	N/A
Rotor 2 Elastic Blade Data Group	80	80 - 8C	N/A
Rotor Aerodynamic Group	90	90 - 9AE	775 - 785
Rotor 1 Rotor-Induced Velocity Distribution (RIVD) Table	100	100 - 100/F	786 - 1029
Rotor 2 RIVD Table	110	110 - 110/C	N/A
Rotor-Wake-at-Aerodynamic-Surface (RWAS) Table Group			
RWAS Table No. 1	***	***	N/A
RWAS Table No. 2	***	***	N/A
RWAS Table No. 3	***	***	N/A
RWAS Table No. 4	***	***	N/A
RWAS Table No. 5	***	***	N/A
RWAS Table No. 6	***	***	N/A
RWAS Table No. 7	***	***	N/A
RWAS Table No. 8	***	***	N/A
RWAS Table No. 9	***	***	N/A

TABLE I (Continued)

GROUP TITLE	AGAP80 SEQUENCE NUMBER OF ID CARD *	AGAP80 SEQUENCE INPUT CARD NUMBERS **	REFERENCE CARD SEQUENCE NUMBER ****
RWAS Table No. 10	***	***	N/A
RWAS Table No. 11	***	***	N/A
RWAS Table No. 12	***	***	N/A
Basic Fuselage Group	120	120 - 125	1030 - 1032
Fuselage Aerodynamic Group or Fuselage Aerodynamic Table	130	130 - 13C	1033 - 1044
Wing Group	140	140 - 14C	1045 - 1055
Stabilizing Surface Groups			
Stabilizing Surface No. 1	150	150 - 15B	1056 - 1065
Stabilizing Surface No. 2	160	160 - 16B	1066 - 1077
Stabilizing Surface No. 3	170	170 - 17B	1078 - 1089
Stabilizing Surface No. 4	180	180 - 18B	N/A
Jet Group	190	190 - 192	N/A
External Store/Aerodynamic Brake Group	200	200 - 204C	N/A
Rotor Controls Group	210	210 - 21B	1090 - 1094
Iteration Logic Group	220	220 - 22B	1095 - 1098
Flight Constants Group	230	230 - 234	1099 - 1103
Bobweight Group	240	240 - 241	N/A
Weapons Group	250	250 - 251	N/A
SCAS Group	260	260 - 264	N/A
Stability Analysis Times Group	270	270 - 272	N/A
Blade Element Data Printout Times Group	280	280 - 282	N/A
Maneuver Time Card	None	291	1104
Maneuver Specification Cards	None	301 - 30Z	1105 - 1110
Maneuver Analysis Cards	None	GDAP80 Input Cards	1111 - 1117

* "None" indicates that the group does not have an identification (ID) card.

** C81 Program AGAP80 version sequence card numbers for input data deck as described in Reference 1.

*** No specific sequence number on RWAS Table Cards.

**** Refers to card sequence number in columns 73 - 80 of sample input data deck in Appendix A.

"N/A" indicates that the group is not included in the sample input data deck.

The terms Quasi-Static and Time-Variant refer to the primary rotor analyses that are used in the procedure. Both analyses can include the effects of blade elasticity (mode shapes other than the rigid body mode shape), but only the Time-Variant analysis can include the interaction of the aerodynamic loads and blade elasticity, i.e., aeroelasticity. In the QS trim procedure, the Quasi-Static rotor analysis is used for both rotor systems. In the QS-TV trim procedure, the standard QS trim is performed first. The rotor modal equations of motion are then numerically integrated for a prescribed number of rotor revolutions using the Time-Variant rotor analysis with the control positions and fuselage orientation held fixed at the positions determined by the QS trim. It is assumed that after a number of revolutions, the aeroelastic effects included in the Time-Variant analysis will have caused the rotor either to stabilize or diverge, depending on the basic stability of the rotor system. The user may select that such Time-Variant trims be computed for either or both rotors. If both rotors are selected, the two Time-Variant trims are computed independently of each other. In the FTV trim procedure, the user specifies the rotor or rotors which use the Time-Variant analysis. In doing so, any reference to the QS trim procedure is deleted for the specified rotor(s). A rotor which does not use the Time-Variant analysis uses the Quasi-Static analysis. Table II shows the type of rotor analysis used for each rotor as a function of the values of IPL(49) and (50).

Trim Procedure

The basic program flow, which is the same for all three types of trim, is shown in figure 9. The three basic blocks in the figure are the computation of the partial derivative matrix (shown in figure 10), the Time-Variant portion of the QS-TV trim (shown in figure 11), and the rotor force and moment computations (shown in figure 12).

Trimmed Flight Printout

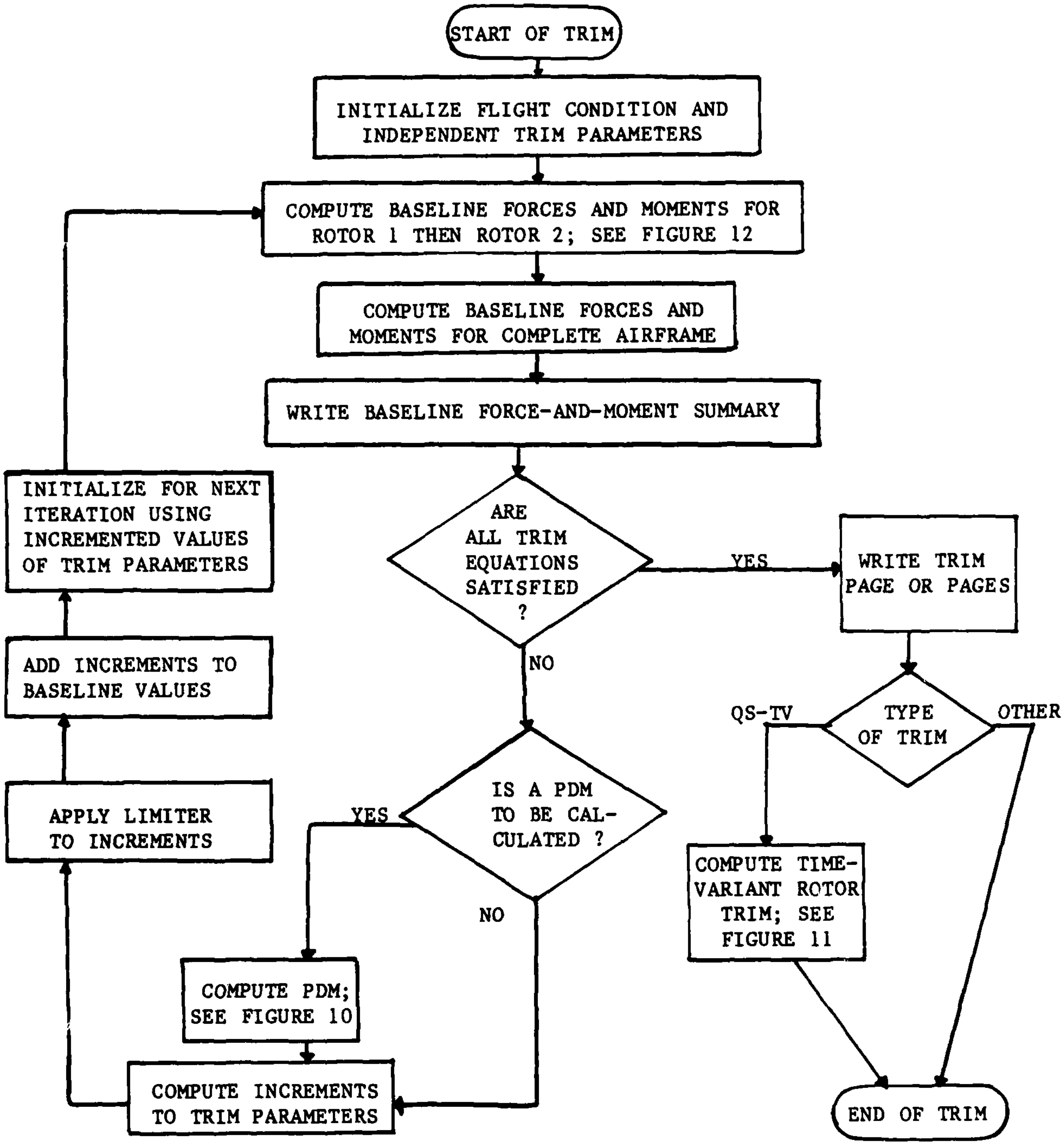
Two types of printouts are possible for the data computed in the last trim iteration, the standard trim page (figure 13) and the optional trim page (figure 14). The standard trim page follows the final trim iteration. The final trim iteration occurs either when all forces and moment imbalances are within their respective allowable errors or after the iteration limit for trim has been reached. These allowable errors and the iteration limit are inputs of the Iteration Logic Group.

Printout of the optional trim page is controlled by IPL(73) (Program Logic Group). The optional trim page is most useful for presenting data from a wind tunnel simulation. The optional trim page contains the following information: 1) problem identification; 2) a parameter listing of rotor controls, rotor parameters, wind tunnel parameters, and program options; 3) rotor forces and moments listed in both wind reference and shaft reference systems, and 4) a summary of the beam, chord, and torsional rotor loads is printed if rotor blade elastic mode shapes have been included in the analysis.

TABLE II ROTOR ANALYSIS USED DURING TRIM AND MANEUVER

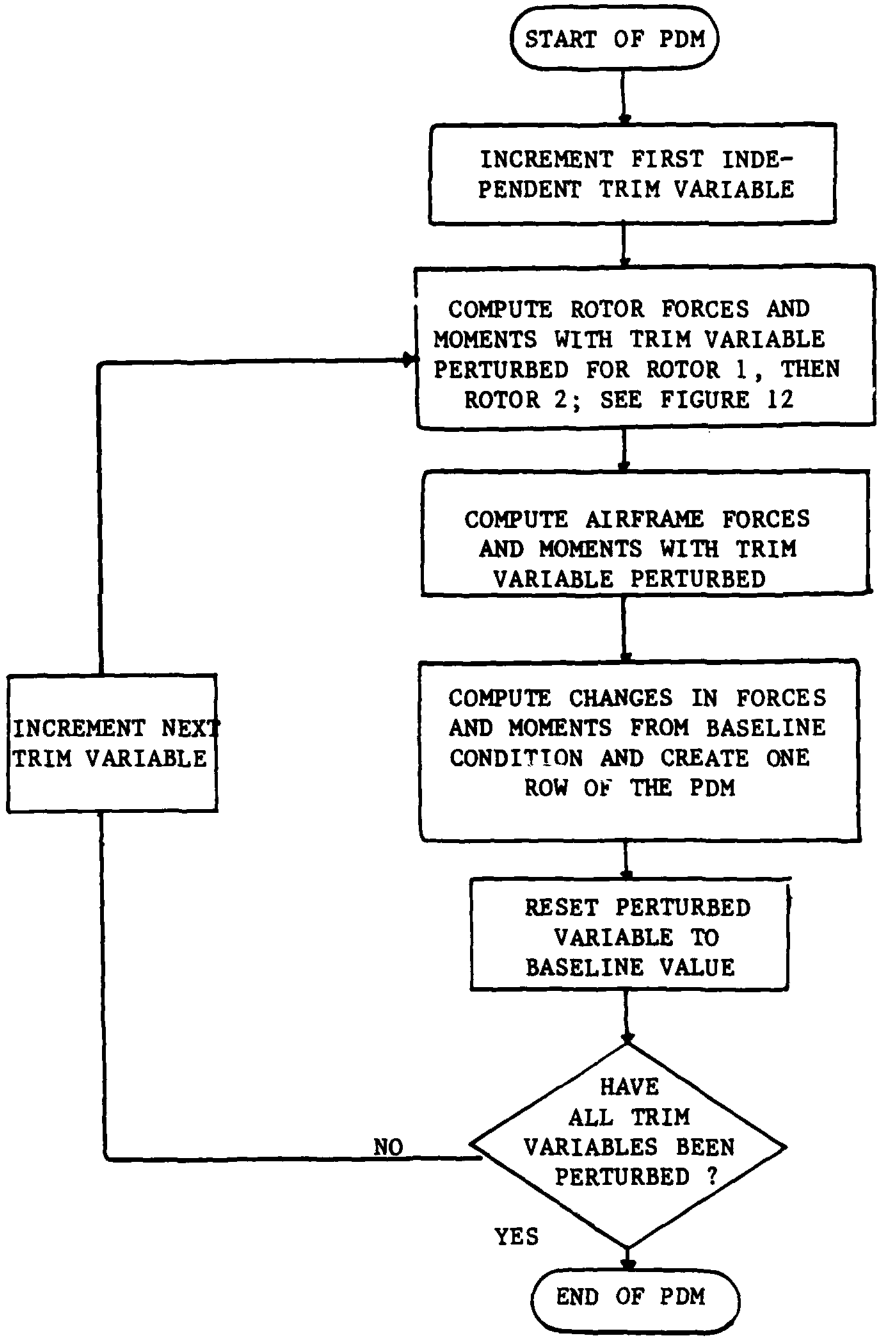
Inputs			Analysis Used	
IPL(49)	IPL(50)	Rotor	In Trim	In Maneuver
0	(Ignored)	1 (Main)	QS	QS
		2 (Tail)	QS	QS
1	0	1	QS-TV	TV
		2	QS	QS
	1	1	QS	TV
		2	QS	QS
	2	1	TV	TV
		2	QS	QS
2	0	1	QS	QS
		2	QS-TV	TV
	1	1	QS	QS
		2	QS	QS
	2	1	QS	QS
		2	TV	TV
3	0	1	QS-TV	TV
		2	QS-TV	TV
	1	1	QS	TV
		2	QS	TV
	2	1	TV	TV
		2	TV	TV

QS = Quasi-Static rotor analysis
TV = Time-Variant rotor analysis
QS-TV = Quasi-Static trim followed by a Time-Variant trim. During the time-variant portion of this type trim, only the flapping, pylon, and mast windup angles of the time-variant rotor are allowed to vary; the fuselage and control positions are held fixed at the values determined by the quasi-static trim. If both rotors are time-variant, they are trimmed independently of each other.



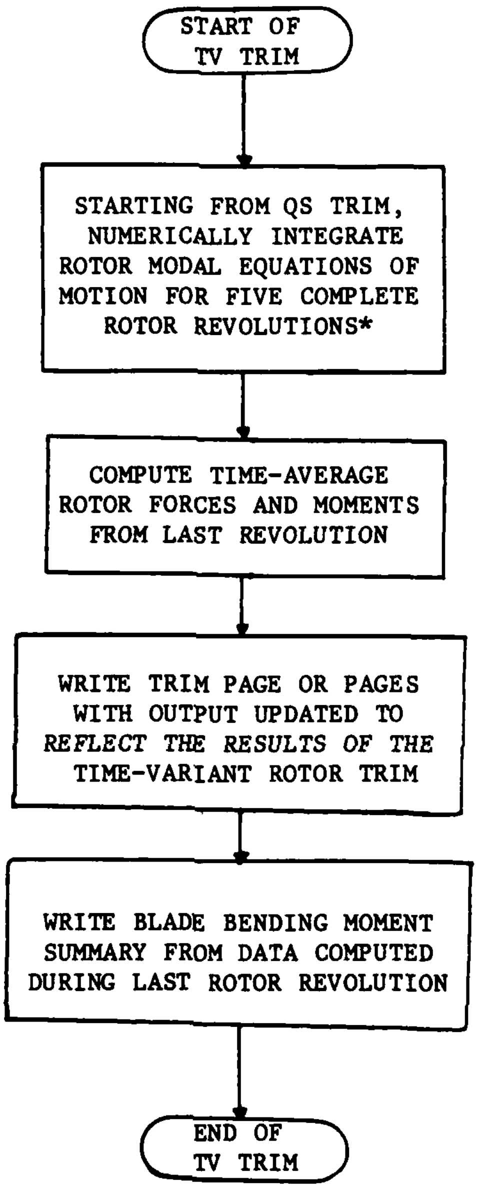
PDM = Partial Derivative Matrix
QS-TV = Quasi-Static Trim Followed by Time-Variant Rotor Trim

Figure 9. Flow Chart of Trim Procedure.



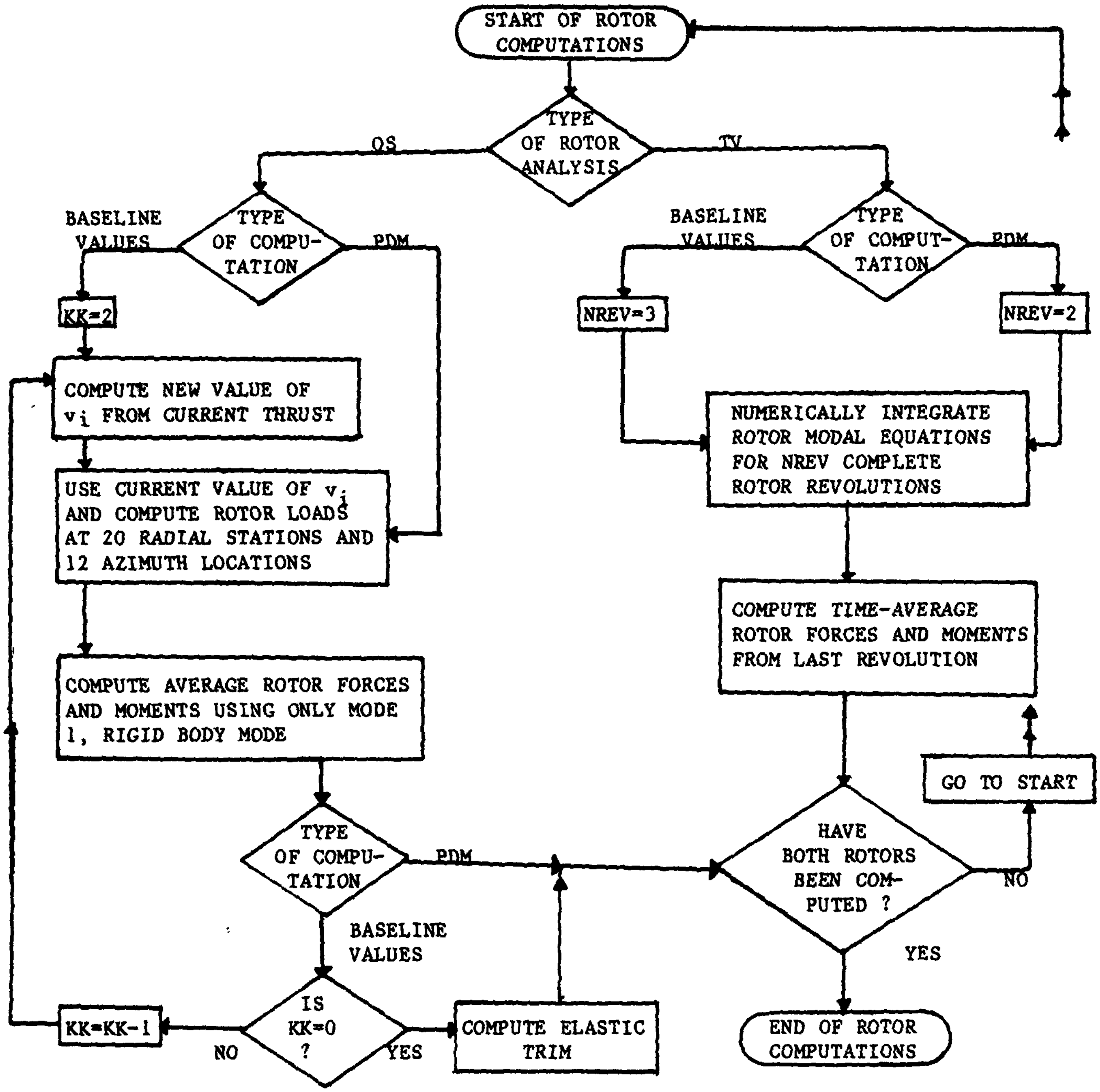
PDM = Partial Derivative Matrix

Figure 10. Flow Chart of Partial Derivative Matrix Computation.



*Control positions and fuselage degrees of freedom held fixed at the final values computed during the QS trim.

Figure 11. Flow Chart of Time-Variant Rotor Trim.



v_i = Rotor-Induced Velocity
PDM = Partial Derivative Matrix
KK = Thrust/v_i Looping Variable

QS = Quasi-Static Rotor Analysis
TV = Time-Variant Rotor Analysis
NREV = Number of Rotor Revolutions in TV Analysis

Figure 12. Flow Chart of Rotor Force and Moment Computations During Trim Procedures.

```
BELL HELICOPTER TEXTRON   ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAP8001   COMPUTED   81/

                 AH-1G + OLS ROTOR SIMULATION    AGAP80 USERS MANUAL CASE
                 SAMPLE TRIM CASE                     INPUT DATA = DAT3
                 129 KT LEVEL FLIGHT AT 2900 HP, 27 DEG C   8319 LB   AFT CG
ROTORCRAFT IS TRIMMED AFTER 16 ITERATIONS.        .358 MINUTES ELAPSED COMPUTING TIME.        NPART = 1

-----------------------------------------ATMOSPHERIC CONDITIONS (ICAO)-----------------------------------------
PRESSURE ALTITUDE  (FT)   2900.         DENSITY ALTITUDE  (FT)   4927.          ALTITUDE ABOVE GROUND  (FT)   1000.00
TEMPERATURE     (DEG C)   27.00         DENSITY RATIO            .8636          SPEED OF SOUND     (FT/SEC)   1140.19

----WEIGHTS-----   CENTER OF GRAVITY (IN)   -----------POWER/TORQUE-----------  -----------BLADE-----------   -JET THRUST-
     POUNDS        S.L.    B.L.    W.L.                SHAFT    TORQUE   SPEED     TIP   ADV BLD   INERTIA        LBS
BASIC A/C 8319.   200.60   0.00   68.00           HORSEPOWER    FT-LB     RPM    SPEED  MACH NO  SLUG-FT-SQ
STORES       0.                                 MAIN   672.81  10904.4   324.1    747.    .846    1503.394    RT    0.0
TOTAL     8319.   200.60   0.00   68.00         TAIL    28.10     89.1  1656.6    737.    .838       1.532    LT    0.0
                                                ENG    700.91    557.8  6600.0

                                          BODY REFERENCE
                           U          V          W          P          Q          R
              VELOCITY   217.848    3.216    -12.552      0.000      0.000      0.000

------FLIGHT PATH CONDITION-------    ---------------------------AERODYNAMIC SURFACES---------------------------
TRUE AIRSPEED     (KNOTS)   129.30                ANGLE OF   FLAP    -----BODY AXIS FORCES-----   AERODYNAMIC ANGLE
GROUND SPEED      (KNOTS)   129.30     SURFACE    INCIDENCE  ANGLE   X +FWD   Y +RIGHT  Z +DOWN    ATTACK  SIDESLIP
RATE OF CLIMB    (FT/SEC)     0.00     NO. 1        4.50      0.00   -13.0     126.4      1.1       3.65    -3.30
CLIMB ANGLE         (DEG)     0.00     NO. 2        2.77      0.00    -2.1       -.1     15.7      -1.23      .84
HEADING ANGLE       (DEG)     0.00
ANGLE OF ATTACK     (DEG)    -3.30     NO. 3        2.77      0.00    -2.1       -.1     15.6      -1.23      .84
ANGLE OF SIDESLIP   (DEG)      .85     NO. 4        0.00      0.00     0.0       0.0      0.0       0.00     0.00
ANGLE OF AERO YAW   (DEG)     -.84
ACCELERATIONS  VERT   (G)     1.00     RT WING     14.00      0.00   -75.4     -29.7   -480.2      10.76     1.03
               FWD    (G)      .06     LT WING     14.00      0.00   -75.0      25.2   -473.3      10.66      .66
               LAT    (G)     -.02

                                        GROUND REFERENCE
                       EULER ANGLES TO BODY REFFRENCE          DISPLACEMENTS
                          PSI       THETA       PHI          X          Y          Z
              VELOCITY   0.000      0.000      0.000      218.233      0.000      0.000
              LOCATION   -.773     -3.315     -1.232

CONTROL DISPLACEMENTS   ------------SWASH PLATE ANGLE (DEGREES)------------   --HUB-MAST-PYLON--------(MAIN)---(TAIL)-
     ---PERCENT---      -------MAIN ROTOR-------   -------TAIL ROTOR-------   DELTA 3         (DEG)      0.0     45.0
                          COLL     F/A     LAT       COLL     F/A     LAT     PHASING         (DEG)      0.00    0.00
COLL        (UP)  38.53   15.43    0.00    0.00      0.00    0.00    0.00     HUB SPRING MOMENT F/A      -0.      0.
F/A CYC    (FWD)  68.62    0.00    5.40    0.00      0.00    0.00    0.00              (FT-LB) LAT        0.      0.
LAT CYC     (RT)  55.62    0.00    0.00   -1.62      0.00    0.00    0.00     PYLON ANGLES      F/A      0.00    0.00
PEDAL       (LT)  47.57    0.00    0.00    0.00     -3.40    0.00    0.00                 (DEG) LAT      0.00    0.00
SUM OF PYLON AND SCAS      0.00    0.00    0.00      0.00    0.00    0.00     MAST ANGLE  (DEG) F/A      0.00    0.00
TOTAL SWASH PLATE ANG     15.43    5.40   -1.62     -3.40    0.00    0.00                       LAT      0.00  -90.00

-----------------------------------------------------ROTORS-----------------------------------------------------
      BLADE FEATHERING - DEG     FLAPPING - DEG     FORCES (SHAFT AXIS) POUNDS      ADVANCE    CP      CT     INDUCED
      MEAN    PSI=0   PSI=90     F/A      LAT       THRUST   H-FORCE   Y-FORCE     RATIO    X105    X104    VELOCITY
MAIN  15.43   1.62    -5.40    -1.662    -.739     7447.61   -79.02   -174.54      .292    28.478  42.791     6.16
TAIL  -3.40  -1.13     1.06    -1.126    1.058     -260.91    17.26     -3.72      .296    33.089 -41.188    -5.73

                        BETA                     SHAFT AXIS DATA AT ROTOR HUB               HUB MOTION (FT)        MAST
      PSI (DEG)    HUB    LIMIT     VELOCITIES (FT/SEC)       SHEAR FORCES (POUNDS)                              WIND-UP
                  (DEG)   (DEG)      U        V        W        X        Y        Z        X       Y       Z      (DEG)
MAIN    0.00      0.00    12.00   217.85     3.22   -12.55    257.5   -249.3  -6161.2   0.000   0.000   0.000    0.000
TAIL    0.00      0.00    11.00   217.85   -12.55     2.57    -17.3     -3.7    260.9   0.000   0.000   0.000    0.000
```

Figure 13. Trimmed Flight Condition Page.

BELL HELICOPTER TEXTRON   ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAP8001   COMPUTED 81/

AH-1G + OLS ROTOR SIMULATION   AGAP80 USER#S MANUAL CASE
SAMPLE TRIM CASE   INPUT DATA = DAT3
129 KT LEVEL FLIGHT AT 2900# HP, 27 DEG C   8319 LB   AFT CG

ROTOR CONTROLS		ROTOR PARAMETERS		TUNNEL PARAMETERS		PROGRAM OPTIONS	
COLLECTIVE PITCH	15.430 DEG	ROTOR SPEED	324.06 RPM	FORWARD SPEED	129.30 KTS	NO INPUT MODES	9
F/A CYCLIC PITCH	5.398 DEG	SOLIDITY	.0631	ADVANCE RATIO	.2923	MX YAW FLOW, TIP	0.0 DEG
LAT CYCLIC PITCH	-1.617 DEG	BLADE RADIUS	22.00 FT	ADV TIP MACH NO	.846	AERODYNAMICS, TIP	TABLE
TOT CYC FEATHER	5.635 DEG	CHORD, AVG	26.18 IN	SIGMA PRIME	.864	TORSION	ON
DELTA 3	0.00 DEG	PRECONE	2.75 DEG	MAST TILT ANGLE	0.00 DEG	NON STEADY AERO	OFF
F/A FLAP ANGLE	-1.636 DEG	CONING	-1.155 DEG	TPP ANG OF ATTACK	-4.93 DEG	FLAP ITERATION	OFF
LAT FLAP ANGLE	-.828 DEG	TWIST	-10.00 DEG	CNT PL ANG OF ATTACK	-8.70 DEG	FREQUENCY CHANGE	OFF
TOTAL FLAP ANGLE	1.833 DEG	TIP SWEEP	0.00 DEG	ROTOR TIP SPEED	746.6 FT/SEC	ELASTIC PYLON	OFF

***** FORCES AND MOMENTS ****,

WIND AXIS SYSTEM	DIMENSIONLESS HELICOPTER	DIMENSIONLESS FIXED-WING	DIMENSIONAL
LIFT FORCE	.0671286	1.2340753	7375.30 LBS
DRAG FORCE	-.0006595	-.0121240	-72.46 LBS
LAT FORCE	-.0015217	-.0279751	-167.19 LBS
ROLL MOMENT	.0000000	.0000000	.00 FT-LBS
PITCH MOMENT	.0000000	.0000000	.00 FT-LBS
YAW MOMENT	.0044252	.0406756	10696.07 FT-LBS

SHAFT AXIS SYSTEM	DIMENSIONLESS HELICOPTER	DIMENSIONLESS FIXED-WING	DIMENSIONAL
THRUST	.0671286	1.2340753	7375.30 LBS
H FORCE	-.0006595	-.0121240	-72.46 LBS
Y FORCE	-.0015217	-.0279751	-167.19 LBS
ROLL MOMENT	.0000000	.0000000	.00 FT-LBS
PITCH MOMENT	.0000000	.0000000	.00 FT-LBS
YAW MOMENT	.0044252	.0406756	10696.07 FT-LBS
POWER	.0044252	.2783048	659.96 HP

* * * * * * ROTOR LOADS * * * * * *

R/R	BEAM LOADS (IN-LBS) MEAN	OSC	/MAX AZ	/MIN AZ	CHORD LOADS (IN-LBS) MEAN	OSC	/MAX AZ	/MIN AZ
0.0	-32570.05	8264.19	280.	30.	3.99	32122.72	330.	150.
.02	-17236.32	4408.29	100.	40.	1497.55	31045.26	330.	150.
.08	-8796.64	13296.55	300.	110.	7099.47	27988.89	330.	150.
.14	-5766.47	16304.99	310.	110.	8279.89	24310.08	330.	150.
.20	-2978.37	13577.27	310.	110.	8754.26	21534.58	330.	150.
.25	-1245.18	9648.66	310.	100.	8821.29	19337.13	330.	150.
.31	-322.95	6922.76	320.	100.	8695.62	16907.79	330.	150.
.35	-155.38	5959.23	320.	90.	8474.74	15326.31	330.	160.
.39	-457.68	5420.40	320.	80.	8141.31	13906.37	330.	160.
.45	-1189.48	5005.37	320.	80.	7463.21	11885.60	330.	160.
.50	-1947.48	4819.81	330.	80.	6758.37	10304.34	330.	160.
.55	-2850.56	5144.66	250.	80.	5941.01	8823.00	330.	160.
.59	-3516.68	5858.24	260.	80.	5183.28	7743.74	330.	150.
.65	-4224.89	6708.00	260.	80.	3973.21	6219.84	330.	150.
.70	-4540.05	6933.39	260.	150.	2951.87	5019.47	330.	150.
.75	-4661.80	6826.39	260.	150.	1989.14	3879.10	330.	150.
.80	-4155.28	5884.85	260.	150.	1125.58	2686.15	330.	150.
.85	-3278.73	4583.27	260.	150.	561.13	1780.65	330.	150.
.90	-1852.99	2522.05	260.	150.	177.55	875.57	330.	90.
.95	-620.70	798.61	260.	150.	22.91	274.61	330.	90.
1.00	0.00	0.00	0.	0.	0.00	0.00	0.	0.

R/R	TORSION LOADS (IN-LBS) MEAN	OSC	/MAX AZ	/MIN AZ
0.0	0.00	0.00	0.	0.
.02	0.00	0.00	0.	0.
.08	-3824.94	5889.01	270.	110.
.14	-3613.97	4496.93	270.	120.
.20	-3803.83	3874.48	270.	140.
.25	-3957.12	3688.60	270.	150.
.31	-3974.51	3608.87	270.	150.
.35	-4030.10	3455.58	270.	150.
.39	-4089.08	3285.94	270.	150.
.45	-4213.25	3008.33	270.	160.
.50	-4334.92	2713.86	270.	160.
.55	-4357.63	2526.99	280.	160.
.59	-4398.61	2430.72	280.	200.
.65	-4440.45	2350.87	280.	200.
.70	-4198.45	2274.15	70.	200.
.75	-3979.33	2140.69	70.	200.
.80	-3696.55	1949.44	60.	170.
.85	-3071.13	1689.00	280.	160.
.90	-2313.85	1336.98	280.	160.
.95	-1302.16	780.36	280.	160.
1.00	0.00	0.00	0.	0.

Figure 14. Optional Trim Page.

ROTORCRAFT STABILITY ANALYSIS

The rotorcraft stability analysis operation uses a trim point or a time point during a maneuver as its initial condition. The stability derivatives are computed by making small independent perturbations to each of the rotorcraft rigid-body degrees of freedom and primary flight controls, computing the forces and moments in the perturbed flight condition, subtracting the values of the forces and moments in the initial condition from those at the perturbed condition, and finally dividing the differences by the appropriate perturbations. Using these derivatives, the roots of the rotorcraft equations of motion, mode shapes associated with the roots, and transfer functions for the rotorcraft system are computed.

Input

The input cards required are the same as for trim only (NPART=1). In order to compute a trimmed flight condition followed by a stability analysis, an NPART=7 card is required. Note that if the Time-Variant rotor analysis is activated for either rotor, a rotorcraft stability analysis cannot be performed. A stability analysis should not be performed for V = 0. That flight condition should be simulated with some small, nonzero, airspeed (typically, 0.001 knot).

Output of Rotorcraft Stability Analysis

The operation of the rotorcraft stability analysis routine (STAB) depends on the numerical evaluation of a number of partial derivatives that appear in the equations of motion for the rotorcraft.

Control Partial Derivative Matrices

Force and Movement Derivatives

Figure 15 presents the control partial derivative matrix as printed out in three ways by the AGAP80 version of C81. The first version of the control partial derivative matrix is printed with units of pounds per inch or foot-pounds per inch. The response to each of the 14 degrees of freedom available in STAB is evaluated and ratioed to be the response to a 1-inch step input from each of the four controls. The rotor flapping angles are changed to reduce the rotor flapping moments to less than the allowable error if the rotor degrees of freedom are not turned on.

Control Derivatives In Terms Of Accelerations

The second version of the control partial derivative matrix contains the same information as the first. In this matrix, the force and moment derivatives have been divided by the appropriate masses or inertias to give the units of linear or angular acceleration per inch of control. These numbers may be thought of as the accelerations at the instant immediately after a step input from the controls.

Conventional Fixed-Wing Nondimensional Derivatives

If the rotorcraft does not have a wing or if the airspeed is less than 1.0 knots, this matrix is not printed. Refer to reference 2 for the nondimensionalizing factors and for interpretation of the first six rows of the third matrix. No attempt will be made to interpret or explain the last four rows of this matrix because conventional fixed-wing concepts do not apply to helicopter rotors and pylons.

Partial Derivatives For Rotorcraft Stability Analysis Degrees Of Freedom

The next pages of output contain detailed information used for the calculation of the partial derivatives for each degree of freedom that is activated in STAB. The partial derivatives are evaluated in the same order in which the variables are listed in the following paragraph. See figure 16.

CONTROL PARTIAL DERIVATIVE MATRICES

POUNDS/INCH OR FOOT-POUNDS/INCH

	COLLECTIVE	F/A CYCLIC	LAT CYCLIC	PEDAL
X-FORCE	139.4	43.01	-32.74	-19.60
Y-FORCE	-139.9	113.0	114.4	518.6
Z-FORCE	-5252.	2931.	33.18	-4.098
YAW MOM	3113.	2048.	-853.1	-.1381E+05
PITCH MOM	-721.8	-1053.	229.6	-102.9
ROLL MOM	-988.5	797.9	807.9	2168.
M.R. F/A FLAP MOM	706.9	-51.81	-.2829E+05	.2348E-07
M.R. LAT FLAP MOM	.3564E+05	-.5836E+05	-28.25	-.3274E-06
T.R. F/A FLAP MOM	0.	0.	0.	31.24
T.R. LAT FLAP MOM	0.	0.	0.	-523.2

FT/SEC2 OR RAD/SEC2 PER INCH

	COLLECTIVE	F/A CYCLIC	LAT CYCLIC	PEDAL
X-FORCE	.5390	.1663	-.1266	-.7580E-01
Y-FORCE	-.5412	.4371	.4424	2.006
Z-FORCE	-20.31	11.34	.1283	-.1585E-01
YAW MOM	.3042	.2001	-.8336E-01	-1.349
PITCH MOM	-.6074E-01	-.8859E-01	.1932E-01	-.8658E-02
ROLL MOM	-.3404	.2747	.2782	.7465
M.R. F/A FLAP MOM	.4702	-.3446E-01	-18.82	.1562E-10
M.R. LAT FLAP MOM	23.70	-38.82	-.1879E-01	-.2176E-09
T.R. F/A FLAP MOM	0.	0.	0.	20.39
T.R. LAT FLAP MOM	0.	0.	0.	-341.5

CONVENTIONAL FIXED WING NON-DIMENSIONAL DERIVATIVES

	COLLECTIVE	F/A CYCLIC	LAT CYCLIC	PEDAL
X-FORCE	.1012	.3124E-01	-.2378E-01	-.1424E-01
Y-FORCF	-.1017	.8211E-01	.8309E-01	.3767
Z-FORCE	-3.815	2.129	.2410E-01	-.2977E-02
YAW MOM	.2169	.1427	-.5945E-01	-.9624
PITCH MOM	-.1942	-.2832	.6175E-01	-.2768E-01
ROLL MOM	-.6889E-01	.5560E-01	.5630E-01	.1511
M.R. F/A FLAP MOM	.1902	-.1394E-01	-7.609	.6315E-11
M.R. LAT FLAP MOM	2.483	-4.067	-.1969E-02	-.2281E-10
T.R. F/A FLAP MOM	0.	0.	0.	.8405E-02
T.R. LAT FLAP MOM	0.	0.	0.	-.3646E-01

Figure 15. Control Partial Derivative Matrix from STAB.

```
    FUS. U =  217.84752  FUS. W =   -7.55214   FUS. Q =    0.00000  FUS. V =    3.21600   FUS. P =    0.00000  FUS. R =    0.00000
M.R. F/A  FLAP  RATE =    0.0000 M.R. LAT  FLAP  RATE =     0.0000 T.R. F/A  FLAP  RATE =    0.0000 T.R. LAT  FLAP  RATE =    0.0000
M.R. F/A  FLAP  DISP =   -1.6825 M.R. LAT  FLAP  DISP =    -.7389 T.R. F/A  FLAP  DISP =   -1.1258 T.R. LAT  FLAP  DISP =    1.0583
```

	THRUST	H-FORCE	Y-FORCE	TORQUE	IND. V.	JET THRUST	
MAIN ROTOR	8750.	-121.	-211.	10678.	6.160	RIGHT/CENTER	0.
TAIL ROTOR	-262.	17.	-4.	89.	-5.729	LEFT	0.

FORCE AND MOMENT SUMMARY

BODY AXIS	X-FORCE	Y-FORCE	Z-FORCE	ROLL	PITCH	YAW
FUSELAGE	-375.3	-26.4	43.4	-176.1	-954.5	-805.0
MAIN ROTOR	121.2	-210.8	-8750.2	-1489.2	-418.4	-10.5
TAIL ROTOR	-17.4	262.1	-4.1	1093.1	-36.0	-6970.1
RIGHT WING	-76.8	-33.3	-538.6	-1281.2	489.7	152.5
LEFT WING	-76.5	27.9	-531.4	1264.1	483.1	-156.6
STABILIZER #1	-12.9	122.4	.7	297.3	47.6	-3069.6
STABILIZER #2	-2.9	-.0	.2	-.2	37.9	5.3
STABILIZER #3	-2.9	-.0	.2	-.6	37.8	-3.8
GROSS WEIGHT	481.1	-178.6	8303.2			
M.R. TORQUE				.0	-.0	10678.0
T.R. TORQUE				0.0	-89.2	-.0
TOTAL	37.4	-36.9	-1476.7	-293.1	-401.9	-179.8

DELTA

FORCE AND MOMENT SUMMARY

BODY AXIS	X-FORCE	Y-FORCE	Z-FORCE	ROLL	PITCH	YAW
FUSELAGE	-.0	3.2	-27.9	-30.9	254.9	-19.0
MAIN ROTOR	42.2	-36.3	-1302.6	-256.4	-232.7	-1.8
TAIL ROTOR	-.1	1.2	-.4	4.5	-9.0	-31.3
RIGHT WING	-1.4	-3.7	-58.4	-138.9	52.9	.0
LEFT WING	-1.5	2.7	-58.1	138.1	52.6	-1.2
STABILIZER #1	.2	-4.0	-.5	-9.7	-11.7	100.9
STABILIZER #2	-.9	.0	-15.5	-24.1	-255.6	1.2
STABILIZER #3	-.9	.0	-15.4	23.9	-253.6	-1.5
GROSS WEIGHT	0.0	0.0	0.0			
M.R. TORQUE				0.0	0.0	-226.3
T.R. TORQUE				0.0	-.1	-.0
TOTAL	37.5	-36.9	-1478.7	-293.5	-402.2	-179.1

Figure 16. Example of Partial Derivatives for STAB Degrees of Freedom.

Rotorcraft Stability Analysis Degrees Of Freedom

At the top of each partial derivative page (figure 16) is a list of the current value of each of the possible degrees of freedom. All FUS (fuselage) parameters are in the body reference system and all M.R. and T.R. (rotor) parameters are in the appropriate shaft reference system. By a comparison of two successive pages, it is possible to tell which variable is being perturbed and by how much.

The 30 variables which may be perturbed are perturbed in the following order:

FUS. U = Velocity in the X direction (FT/SEC)

FUS. W = Velocity in the Z direction (FT/SEC)

FUS. Q = Pitch Rate (DEG/SEC)

FUS. V = Velocity in the Y direction (FT/SEC)

FUS. P = Roll rate (DEC/SEC)

FUS. R = Yaw rate (DEG/SEC)

M.R. PYLON MODE 1 RATE = (DEG/SEC)

M.R. PYLON MODE 2 RATE = (DEG/SEC)

M.R. PYLON MODE 3 RATE = (DEG/SEC)

M.R. PYLON MODE 4 RATE = (DEG/SEC)

T.R. PYLON MODE 1 RATE = (DEG/SEC)

T.R. PYLON MODE 2 RATE = (DEG/SEC)

T.R. PYLON MODE 3 RATE = (DEG/SEC)

T.R. PYLON MODE 4 RATE = (DEG/SEC)

M.R. F/A FLAP RATE = (DEG/SEC)

M.R. LAT FLAP RATE = (DEG/SEC)

T.R. F/A FLAP RATE = (DEG/SEC)

T.R. LAT FLAP RATE = (DEG/SEC)

M.R. PYLON MODE 1 DISP = (DEG)

M.R. PYLON MODE 2 DISP = (DEG)

M.R. PYLON MODE 3 DISP = (DEG)

M.R. PYLON MODE 4 DISP = (DEG)

T.R. PYLON MODE 1 DISP = (DEG)

T.R. PYLON MODE 2 DISP = (DEG)

T.R. PYLON MODE 3 DISP = (DEG)

T.R. PYLON MODE 4 DISP = (DEG)

M.R. F/A FLAP DISP = (DEG)

M.R. LAT FLAP DISP = (DEG)

T.R. F/A FLAP DISP = (DEG)

T.R. LAT FLAP DISP = (DEG)

Each partial derivative page (figure 16) gives rotor performance data, a force and moment summary, and a delta force and moment summary. The forces and moments printed here are computed after the small increment in the pertinent variable has been made. All data are in the body reference system. The delta force and moment summary presents the changes in the force and moment contributions in exactly the same format as the full force and moment summary. Each number in this data block is obtained by taking the corresponding value from the force and moment summary immediately above, less the corresponding value at the trim condition or at the current maneuver time point.

Rotorcraft Stability Partial Derivative Matrices

Total Partial Derivative Matrix

A summary of the partial derivatives computed from the data on the previous pages is then printed (figure 17). Each row gives the partial derivatives of some total aircraft force or moment, as labeled, with respect to the perturbation variables used.

Rotor Partial Derivative Matrix

A summary of the rotor partial derivatives computed from the data on the previous pages is printed on this page as well (figure 17). Each row gives the partial derivatives of some force, moment, or flapping angle, as labeled, with respect to the linear and angular velocities U, V, W, P, Q, and R.

Mass, Damping, and Stiffness Matrices

The mass, damping, and stiffness matrices (figure 18) which are used to calculate the rotorcraft stability characteristics are printed next. Refer to Volume I of reference 3 for the analytical background of these three matrices.

Stick-Fixed Rotorcraft Stability Results

The rotorcraft characteristic equation, with controls fixed, is solved for its complex roots and associated response modes. The results are presented in several ways (figure 18).

STABILITY PARTIAL DERIVATIVES (TOTAL AIRCRAFT)

	U	W	Q	V	P	R
X-FORCE	-8.2534	7.4934	57.797	1.8645	44.783	-17.359
Z-FORCE	-8.6935	-295.74	-121.41	-6.9757	-1163.3	657.08
PITCH MOMENT	22.591	-80.434	-2357.6	-.95633	-245.39	64.117
Y-FORCE	.74759	-7.3835	-19.841	-54.454	-139.40	590.16
ROLL MOMENT	-3.8791	-58.691	-61.756	-106.96	-760.97	2106.3
YAW MOMENT	-23.472	-35.811	1368.8	291.67	888.60	-16410.
M.R. F/A FLAP MOM	44.301	21.681	31546.	420.80	.10482E+06	-863.63
M.R. LAT FLAP MOM	324.38	1130.0	-.10435E+06	104.47	33947.	1959.2
T.R. F/A FLAP MOM	-.69175	-1.7627	-44.757	-.36629	-535.80	-42.764
T.R. LAT FLAP MOM	-1.4896	-.97511E-01	5.8013	5.8005	-21.922	340.00

	M.R. F/A FLAP RATE	M.R. LAT FLAP RATE	T.R. F/A FLAP RATE	T.R. LAT FLAP RATE	M.R. F/A FLAP DISP	M.R. LAT FLAP DISP	T.R. F/A FLAP DISP	T.R. LAT FLAP DISP
X-FORCE	44.182	36.343	.43669	-.18023E-02	-4506.4	109.70	159.13	143.12
Z-FORCE	-14.203	-1114.7	-.52666	-.34991	15016.	-8084.8	251.86	-137.84
PITCH MOMENT	-311.36	-200.97	-14.754	-5.0107	31079.	-370.64	5737.5	-3549.3
Y-FORCE	-10.364	-52.031	.46426	-7.2366	274.32	2168.1	-22.791	-2712.4
ROLL MOMENT	-73.203	-367.51	1.3260	-30.727	1937.6	15314.	200.46	-11525.
YAW MOMENT	1083.0	-988.75	-12.896	193.02	40181.	12342.	420.90	72179.
M.R. F/A FLAP MOM	31967.	-20.192	-.10834E-07	-.10834E-07	.22287E+06	.10967E+07	-.21668E-07	-.21668E-07
M.R. LAT FLAP MOM	-19.897	33196.	.15137E-06	.15137E-06	-.97956E+06	.24754E+06	.13934E-06	.13934E-06
T.R. F/A FLAP MOM	-.18102E-09	-.18102E-09	56.005	.26472	-.18102E-09	-.18102E-09	9995.6	10054.
T.R. LAT FLAP MOM	.36204E-09	.36204E-09	.26471	52.125	.36204E-09	.36204E-09	-8636.3	10164.

ROTOR PARTIAL DERIVATIVE MATRICES

MAIN ROTOR

	U	W	Q	V	P	R
THRUST	-1.1226	260.52	8.3509	7.2726	1163.8	-656.92
H-FORCE	2.9706	-8.4318	-64.175	-.92693	-42.734	3.7979
F/A FLAPPING	0.	0.	0.	0.	0.	0.
Y-FORCE	-.80820	-7.2596	-5.7969	-2.5380	-69.964	12.692
TORQUE	14.027	-45.268	1030.4	9.2164	-922.93	-1400.0
LAT FLAPPING	0.	0.	0.	0.	0.	0.

TAIL ROTOR

	U	W	Q	V	P	R
THRUST	-.69076E-01	-.23570	-9.1659	10.444	47.261	-348.15
H-FORCE	.15840	.24170E-01	.59351	-.35185	-1.8022	11.810
F/A FLAPPING	0.	0.	0.	0.	0.	0.
Y-FORCE	.23355E-01	-.71602E-01	-2.0642	.85600E-01	.73038	-2.3812
TORQUE	.63035	.14523E-01	1.0406	.19792	6.4466	-15.942
LAT FLAPPING	0.	0.	0.	0.	0.	0.

Figure 17. Rotor and Total Partial Derivative Matrices.

MASS MATRIX

	U DOT	W DOT	Q DOT	V DOT	P DOT	R DOT
X-FORCE	256.57	0.	0.	0.	0.	0.
Z-FORCE	0.	258.61	0.	0.	0.	0.
PITCH MOMENT	0.	.56205	11883.	0.	0.	0.
Y-FORCE	0.	0.	0.	256.57	0.	0.
ROLL MOMENT	0.	0.	0.	0.	2904.0	585.00
YAW MOMENT	0.	0.	0.	0.	585.00	10234.
M.R. F/A FLAP MOM	0.	0.	-1503.4	0.	0.	0.
M.R. LAT FLAP MOM	0.	0.	0.	0.	-1503.4	0.
T.R. F/A FLAP MOM	0.	0.	-.27498E-08	0.	0.	1.5320
T.R. LAT FLAP MOM	0.	0.	0.	0.	1.5320	0.

	M.R. F/A FLAP ACC.	M.R. LAT FLAP ACC.	T.R. F/A FLAP ACC.	T.R. LAT FLAP ACC.
X-FORCE	0.	0.	0.	0.
Z-FORCE	0.	0.	0.	0.
PITCH MOMENT	0.	0.	0.	0.
Y-FORCE	0.	0.	0.	0.
ROLL MOMENT	0.	0.	0.	0.
YAW MOMENT	0.	0.	0.	0.
M.R. F/A FLAP MOM	-1503.4	0.	0.	0.
M.R. LAT FLAP MOM	0.	-1503.4	0.	0.
T.R. F/A FLAP MOM	0.	0.	-1.5320	0.
T.R. LAT FLAP MOM	0.	0.	0.	-1.5320

DAMPING MATRIX

	U	W	Q	V	P	R
X-FORCE	8.2534	-7.4934	-3303.5	0.	0.	0.
Z-FORCE	8.8935	295.74	-56308.	0.	0.	0.
PITCH MOMENT	-22.591	80.434	2357.6	0.	0.	0.
Y-FORCE	0.	0.	0.	54.454	3385.1	55839.
ROLL MOMENT	0.	0.	0.	106.96	760.97	-2106.3
YAW MOMENT	0.	0.	0.	-291.67	-888.60	16410.
M.R. F/A FLAP MOM	-44.301	-21.681	-31546.	-420.80	-.10482E+06	863.63
M.R. LAT FLAP MOM	-324.38	-1130.0	.10435E+06	-104.47	-33947.	-1959.2
T.R. F/A FLAP MOM	.69175	1.7627	44.757	.36629	535.80	42.764
T.R. LAT FLAP MOM	1.4896	.97511E-01	-5.8013	-5.8005	21.922	-340.00

	M.R. F/A FLAP RATE	M.R. LAT FLAP RATE	T.R. F/A FLAP RATE	T.R. LAT FLAP RATE
X-FORCE	-44.182	-36.343	-.43669	.18023E-02
Z-FORCE	14.203	1114.7	.52666	.34991
PITCH MOMENT	311.36	200.97	14.754	5.0107
Y-FORCE	10.364	52.031	-.46426	7.2366
ROLL MOMENT	73.203	367.51	-1.3260	30.727
YAW MOMENT	-1083.0	988.75	12.896	-193.02
M.R. F/A FLAP MOM	-31967.	-.10202E+06	0.	0.
M.R. LAT FLAP MOM	.10206E+06	-33196.	0.	0.
T.R. F/A FLAP MOM	0.	0.	-56.005	-531.80
T.R. LAT FLAP MOM	0.	0.	531.27	-52.125

Figure 18. Stability Matrices and Stick-Fixed Stability Results.

STIFFNESS MATRIX

	X	Z	THETA	Y	PHI	PSI
X-FORCE	.0	.0	8303.5	.0	.0	.0
Z-FORCE	.0	.0	-475.76	.0	.0	.0
PITCH MOMENT	.0	.0	.0	.0	.0	.0
Y-FORCE	.0	.0	.0	.0	-8303.5	475.76
ROLL MOMENT	.0	.0	.0	.0	.0	.0
YAW MOMENT	.0	.0	.0	.0	.0	.0
M.R. F/A FLAP MOM	.0	.0	.0	.0	.0	.0
M.R. LAT FLAP MOM	.0	.0	.0	.0	.0	.0
T.R. F/A FLAP MOM	.0	.0	.0	.0	.0	.0
T.R. LAT FLAP MOM	.0	.0	.0	.0	.0	.0

	M.R. F/A FLAP DISP	M.R. LAT FLAP DISP	T.R. F/A FLAP DISP	T.R. LAT FLAP DISP
X-FORCE	4727.2	59.707	-168.70	-150.23
Z-FORCE	-14145.	8355.9	-255.23	142.58
PITCH MOMENT	-32683.	-839.60	-5768.3	3673.8
Y-FORCE	-348.72	-2179.0	21.134	2714.3
ROLL MOMENT	-2463.1	-15391.	-211.35	11538.
YAW MOMENT	-31682.	-13599.	-365.23	-72220.
M.R. F/A FLAP MOM	-.22123E+06	-.10993E+07	.0	.0
M.R. LAT FLAP MOM	.98256E+06	-.24636E+06	.0	.0
T.R. F/A FLAP MOM	.0	.0	-9960.3	-10007.
T.R. LAT FLAP MOM	.0	.0	8604.9	-10121.

CONTROLS-FIXED ROOTS AND TRANSFER FUNCTION DENOMINATOR

	ROOTS REAL	ROOTS IMAG	DENOMINATORS TAU	DENOMINATORS DAMP	PERIOD	TIME TO HALF-DBL	CYCLES TO HALF-DBL	UNDAMPED NAT FREQ RAD/SEC	UNDAMPED NAT FREQ CPS	DAMPING RATIO
# 1	-.34852	.37778	3.7852	2.6384	16.632	1.989	0.120	.514	.818E-01	0.67806
# 2	.10936D-01	.26602	14.107	-.30854	23.619	63.383	2.684	.266	.424E-01	-0.04107
# 3	-.88739	.80276	.69838	1.2395	7.827	0.781	0.100	1.20	.190	0.74158
# 4	-1.1482	2.0657	.17904	.41113	3.042	0.604	0.198	2.36	.376	0.48583
# 5	-9.6961	.27492	.10628E-01	.20610	22.854	0.071	0.003	9.70	1.54	0.99960
# 6	-17.368	17.131	.16803E-02	.58368E-01	0.367	0.040	0.109	24.4	3.88	0.71194
# 7	-11.456	68.401	.20790E-03	.47634E-02	0.092	0.061	0.659	69.4	11.0	0.16518
# 8	-17.658	364.10	.75254E-05	.26577E-03	0.017	0.039	2.275	365.	58.0	0.04844

Figure 18. Concluded

The real and imaginary parts of the roots of the rotorcraft characteristic equation are printed under the headings REAL and IMAG. The units are radians per second. The roots may be used to form the denominator, d(s), of the frequency response polynomial.

$$d(s) = \prod_{i=1}^{n} (s - REAL_i + IMAG_i * j)\ (s - REAL_i - IMAG_i * j)$$

where
- s = Laplace operator
- Π = Continued product notation
- j = $\sqrt{-1}$
- n = Number of roots printed
- i = Sequence number of root in printout

Note that in the case of complex conjugate parts of roots, only the root with the positive imaginary part is printed.

Each root or pair of roots generates the terms in one factor of the denominator of the Laplace transfer function, D(s).

$$D(s) = \prod_{i=1}^{n} (TAU_i * s^2 + DAMP_i * s + 1)$$

where

$$TAU_i = 1/(REAL_i^2 + IMAG_i^2) = 1/\omega_{n_i}^2$$

$$DAMP_i = -2 * REAL_i / (REAL_i^2 + IMAG_i^2) = -2\ \zeta_i / \omega_{n_i}$$

and Π, n, and i are as defined above.

For the oscillatory roots of the rotorcraft characteristic equation, the PERIOD of the damped oscillation is given in seconds. For the roots with a zero imaginary part, the period is a meaningless concept, so a zero appears in the output.

The column headed TIME TO HALF-DBL depends on the value of the real part of the root. If the real part is negative, the time to half amplitude, in seconds, is printed. If the real part is positive, the time to double amplitude, in seconds, is printed. The column headed CYCLES TO HALF-DBL contains the number of cycles to half or double amplitude based on the damped natural frequency (ω_d = IMAG) for the oscillatory roots. A zero is printed for aperiodic roots.

The UNDAMPED NATURAL FREQ, ω_n, is based on the absolute value of the complex root.

$$\omega_n = \sqrt{REAL^2 + IMAG^2}$$

Thus, ω_n is defined even for an aperiodic root. The calculated value of ω_n is given both in radians per second and cycles per second. The DAMPING RATIO, ζ, in combination with the undamped natural frequency, completely describes the root.

$$\zeta = REAL / \omega_n \qquad ; \qquad REAL = \zeta\ \omega_n$$

For a stable aperiodic root, the damping ratio is 1. For an unstable aperiodic root, the damping ratio is -1.

In the stability mode shape printout (figure 19), each column represents one mode. The first column on the left is associated with the first root printed, the second with the second root, and so forth. Each component of a mode shape has a relative magnitude (MAGN) and a phase angle (PHASE). The normal printout provides for eight columns (mode shapes of roots). If more than eight roots are computed, the additional roots are printed in the same format below the first set. Columns after the last root are set to zero.

The mode shapes associated with the rotorcraft characteristic roots are first printed as normalized with respect to THETA, then as normalized with respect to PHI, and lastly as normalized with respect to the largest variable for a given root. In all three sets of normalized mode shapes, the normalizing variable always has a magnitude of 1.000 (nondimensional) and a phase angle of 0.0 degrees. The reader should see reference 1, section 6 for a description of the variables used for the mode shapes.

Transfer Function Numerator

Following the mode shapes, the numerators of the transfer functions (figure 20) for aircraft response and/or flapping angles as specified by IPL(93) are printed. Table III gives the value of IPL(93) required to print the numerators of the transfer functions computed by STAB. For each of the numerators printed, the value labeled GAIN is the constant term in the frequency response polynomial; STATIC GAIN is the gain term to be used in the Laplace transfer function.

The complex roots of the frequency response polynominal are printed in pairs of columns labeled REAL and IMAG. Below the real and imaginary roots are the corresponding values in the numerator of the Laplace transfer function, TAU and DAMP. The numerator of the Laplace transfer function N(s), may be written as follows:

$$N(s) = \text{STATIC GAIN} * \prod_{k=1}^{m} (\text{TAU}_k * s^2 + \text{DAMP}_k * s + 1)$$

The STATIC GAIN is the ratio N(s)/D(s) evaluated for s = 0.

The frequency response polynomial as

$$n(s) = (\text{GAIN}) * \prod_{k=1}^{m} [(s - \text{REAL}_k + \text{IMAG}_k * j) \underbrace{(s - \text{REAL}_k - \text{IMAG}_k * j)}_{\text{only if IMAG} \neq 0}]$$

where k = sequence number of root
m = total number of roots printed

Zero roots are not printed for either the stick fixed or control input solutions, so the final order of the transfer function generated as described above may be incorrect. In this case usually one more "s" in the denominator will correct the situation. The need for this correction may be found by inspecting the numerator and denominator polynomials. The transfer function is correct when the highest power of "s" for the denominator is 2 larger than that for the numerator.

Frequency Response

The frequency response of the transfer functions (figure 21) is tabulated following the transfer function numerator printout. The data listed are the frequency in hertz and radians per second, the gain in the decibel equivalent of a magnitude in degrees per inch of control, and the phase in degrees. The range of frequencies is 0.01 to 100 radians per second. Construction of a Bode plot for each transfer function is greatly simplified with these data.

C O N T R O L S - F I X E D   M O D E   S H A P E S

ROOT	# 1 MAGN PHASE	# 2 MAGN PHASE	# 3 MAGN PHASE	# 4 MAGN PHASE	# 5 MAGN PHASE	# 6 MAGN PHASE	# 7 MAGN PHASE	# 8 MAGN PHASE
----- NORMALIZED WRT THETA -------------								
FUSELAGE								
U/VELOCITY	.7122E-01 -75.76	.5445 92.51	.1842 25.11	.1573 14.64	.3620 -1.014	.1023 -131.6	1.947 -83.93	2.514 116.9
ALPHA	10.49 141.8	.2307 72.29	1.349 62.91	1.379 158.3	.2691 -8.153	.9972 3.657	29.97 -24.58	2.871 80.01
THETA	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0
BETA	62.69 25.26	.4751E-01 -48.34	.3421 168.7	68.29 175.0	.5164 -115.6	9.979 -41.75	4.132 -2.612	66.46 -132.5
PHI	1044. 41.44	1.054 25.76	2.714 134.7	125.9 159.6	1.905 139.8	8.708 -50.29	4.212 -82.43	19.19 156.9
PSI	369.6 -106.4	.5278 -65.19	.7891 -17.78	79.69 -6.266	.5066 33.23	11.69 130.4	2.342 159.2	26.39 -23.04
M.R. F/A FLAP	7.248 158.9	.5901E-01 75.36	.3348 29.28	2.751 -103.1	32.88 -5.698	1.252 -73.72	1817. -112.6	.9946 -169.8
M.R. LAT FLAP	50.13 -11.17	.4138E-01 -84.27	.2639 88.36	30.74 76.06	29.28 139.4	11.61 158.1	1820. 158.1	19.18 -23.03
T.R. F/A FLAP	9.562 143.6	.6729E-02 56.06	.5262E-01 -117.3	7.819 -142.7	.8463 -51.78	946.6 -58.44	2.573 -169.2	.3367E+06 -151.8
T.R. LAT FLAP	20.56 -175.9	.2723E-01 102.8	.9045E-01 -57.47	13.46 -60.30	.4081 -12.19	941.3 36.19	5.088 -71.06	.3367E+06 118.2
----- NORMALIZED WRT PHI -------------								
FUSELAGE								
U/VELOCITY	.6823E-04 -117.2	.5166 66.74	.6789E-01 -109.5	.1249E-02 -144.9	.1900 -140.8	.1178E-01 -81.31	.4623 -1.494	.1310 -39.94
ALPHA	.1004E-01 100.4	.2189 46.53	.4970 -71.75	.1098E-01 -1.265	.1413 -148.0	.1145 53.95	7.117 57.85	.1496 -76.85
THETA	.9580E-03 -41.44	.9489 -25.76	.3685 -134.7	.7941E-02 -159.6	.5249 -139.8	.1148 50.29	.2374 82.43	.5212E-01 -156.9
BETA	.6006E-01 -16.18	.4508E-01 -74.10	.1261 34.00	.5423 15.46	.2710 104.6	1.146 8.537	.9810 79.82	3.464 70.68
PHI	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0
PSI	.3541 -147.8	.5008 -90.96	.2908 -152.4	.6328 -168.8	.2659 -106.6	1.342 -179.3	.5560 -118.4	1.375 -179.9
M.R. F/A FLAP	.6944E-02 117.4	.5600E-01 49.60	.1234 -105.4	.2185E-01 97.34	17.26 -145.5	.1438 -23.43	431.4 -30.21	.5184E-01 33.34
M.R. LAT FLAP	.4802E-01 -62.61	.3927E-01 -110.0	.9726E-01 -46.29	.2441 -83.51	15.37 -.4512	1.333 -184.6	432.1 -119.5	.9998 -179.9
T.R. F/A FLAP	.9160E-02 102.1	.6384E-02 30.29	.1939E-01 108.0	.6209E-01 87.69	.4442 168.4	108.7 -8.153	.6118 -86.79	.1755E+05 51.34
T.R. LAT FLAP	.1970E-01 142.7	.2884E-01 77.03	.3333E-01 167.9	.1069 148.1	.2142 -152.0	108.1 86.48	1.208 11.37	.1755E+05 -38.66

Figure 19. Mode Shapes of Stability Results.

----- NORMALIZED WRT LARGEST -----------

FUSELAGE								
U/VELOCITY	.6823E-04 -117.2	.5166 66.74	.6789E-01 -109.5	.1249E-02 -144.9	.1101E-01 4.684	.1081E-03 -73.16	.1070E-02 118.0	.7467E-05 -1.279
ALPHA	.1004E-01 100.4	.2189 46.53	.4970 -71.75	.1095E-01 -1.265	.8185E-02 -2.455	.1053E-02 62.10	.1647E-01 177.3	.8525E-05 -38.19
THETA	.9580E-03 -41.44	.9489 -25.76	.3685 -134.7	.7941E-02 -159.6	.3042E-01 5.698	.1056E-02 58.44	.5494E-03 -158.1	.2970E-05 -118.2
BETA	.6006E-01 -16.18	.4508E-01 -74.10	.1261 34.00	.5423 15.46	.1571E-01 -109.9	.1054E-01 16.69	.2270E-02 -160.7	.1974E-03 109.3
PHI	1.000 .0	1.000 .0	1.000 .0	1.000 .0	.5795E-01 145.5	.9200E-02 8.153	.2314E-02 119.5	.5698E-04 38.66
PSI	.354[illegible] -147.8	.5008 -90.96	.2908 -152.4	.6328 -165.8	.1541E-01 38.93	.1235E-01 -171.1	.1287E-02 1.069	.7836E-04 -141.2
M.R. F/A FLAP	.6944E-02 117.4	.5600E-01 49.60	.1234 -105.4	.2185E-01 97.34	1.000 .0	.1323E-02 -15.28	.9983 89.26	.2954E-05 72.00
M.R. LAT FLAP	.4802E-01 -62.61	.3927E-01 -110.0	.9726E-01 -46.29	.2441 -83.81	.8906 145.1	.1227E-01 -146.5	1.000 .0	.5696E-04 -141.2
T.R. F/A FLAP	.9160E-02 102.1	.6384E-02 30.29	.1939E-01 108.0	.6209E-01 57.69	.2574E-01 -46.08	1.000 .0	.1414E-02 32.68	.9998 90.00
T.R. LAT FLAP	.1970E-01 142.7	.2584E-01 77.03	.3333E-01 167.9	.1069 140.1	.1241E-01 -6.489	.9944 94.64	.2795E-02 130.8	1.000 .0

Figure 19. Concluded

TRANSFER FUNCTION DATA

NUMERATORS

THETA / LONG CYC		PHI / LAT CYC		PSI / PEDAL	
GAIN =	.81003E-01	GAIN =	-.30594	GAIN =	1.4051
REAL	IMAG	REAL	IMAG	REAL	IMAG
-.34930	.37822	-.80827E-02	.0	.87665E-02	.26312
-.24734E-01	.0	.61130E-02	.25909	.24955	.67966
-1.2275	.0	-.83665	.83089	-.86816	.79566
-1.1385	2.0634	-.85934	2.1074	-1.4659	.0
-10.056	.0	-9.3657	.0	-9.6502	.18123
-17.379	17.133	-16.720	.0	-17.546	14.688
-34.650	.0	-17.471	17.047	-11.460	68.401
-3.8917	63.499	-7.5434	65.226	-15.219	361.84
-17.658	364.10	-17.657	364.10	.0	.0

STATIC GAIN =	.75377E-01	STATIC GAIN =	-.11928E-01	STATIC GAIN =	.59577
TAU	DAMP	TAU	DAMP	TAU	DAMP
3.7727	2.6356	.0	123.72	14.428	-.25297
.0	40.430	14.889	-.18204	1.9076	-.95208
.0	.81469	.71924	1.2035	.72110	1.2521
.18005	.40999	.19306	.33181	.0	.68216
.0	.99445E-01	.0	.10677	.10734E-01	.20716
.16791E-02	.58362E-01	.0	.59810E-01	.19099E-02	.67021E-01
.0	.28860E-01	.16783E-02	.58643E-01	.20790E-03	.47650E-02
.24708E-03	.19232E-02	.23195E-03	.34993E-02	.76245E-05	.23207E-03
.75254E-05	.26577E-03	.75254E-05	.26575E-03	.0	.0

Figure 20. Numerator of Transfer Functions.

TABLE III VALUES OF IPL(93) TO PRINT THE NUMERATORS OF THE TRANSFER FUNCTIONS

Denominator Of Transfer Function	Numerator of Transfer Function							
							M/R Flapping	
	u	w	θ	v	φ	ψ	Long.	Lat.
Collective	2	1	1	3	3	3	4,-1	4,-1
Long. Cyclic	2	1	0,-1	3	3	3	4,-1	4,-1
Lat. Cyclic	3	3	3	2	0,-1	1	4,-1	4,-1
Pedal	3	3	3	2	1	0,-1	4,-1	4,-1

FREQUENCY RESPONSE

FREQ(RAD/SEC)	GAIN(DB)	PHASE(DEG)	GAIN(DB)	PHASE(DEG)	GAIN(DB)	PHASE(DEG)	FREQ(HZ)
0.0100	13.377	21.899	40.725	-40.476	70.663	-91.858	0.0016
0.0125	13.715	26.668	40.059	-34.798	68.724	-92.322	0.0020
0.0160	14.257	32.715	39.528	-29.248	66.679	-92.973	0.0025
0.0200	14.942	38.731	39.197	-25.063	64.639	-93.717	0.0032
0.0250	15.842	45.022	38.971	-21.740	62.699	-94.648	0.0040
0.0300	16.749	50.156	38.842	-19.668	61.112	-95.579	0.0048
0.0350	17.636	54.359	38.761	-18.359	59.770	-96.513	0.0056
0.0400	18.490	57.824	38.707	-17.546	58.606	-97.447	0.0064
0.0500	20.088	63.133	38.640	-16.840	56.659	-99.321	0.0080
0.0600	21.545	66.958	38.599	-16.869	55.063	-101.20	0.0095
0.0700	22.885	69.817	38.569	-17.326	53.710	-103.10	0.0111
0.0800	24.133	72.026	38.545	-18.056	52.533	-105.00	0.0127
0.1000	26.437	75.221	38.498	-20.013	50.551	-108.84	0.0159
0.1250	29.133	77.943	38.428	-22.993	48.538	-113.73	0.0199
0.1600	32.948	80.861	38.263	-27.637	46.234	-120.75	0.0255
0.2000	38.142	84.979	37.819	-33.032	43.967	-128.99	0.0318
0.2500	49.971	109.78	33.794	-45.002	40.356	-141.55	0.0398
0.3000	45.491	-123.05	39.843	-64.164	40.637	-159.09	0.0477
0.3500	38.633	-113.68	38.863	-68.176	38.409	-169.66	0.0557
0.4000	35.148	-112.25	38.152	-76.620	36.334	176.80	0.0637
0.5000	31.133	-113.54	36.535	-94.223	32.203	146.75	0.0796
0.6000	28.621	-116.67	34.580	-109.48	28.364	113.73	0.0955
0.7000	26.744	-120.65	32.487	-121.55	25.616	79.488	0.1114
0.8000	25.186	-125.13	30.419	-130.84	24.336	49.071	0.1273
1.0000	22.504	-134.65	26.620	-143.62	24.029	8.9219	0.1592
1.2500	19.471	-145.86	22.561	-153.31	24.304	-18.447	0.1989
1.6000	15.568	-158.16	17.816	-160.60	24.458	-43.747	0.2546
2.0000	11.660	-167.68	13.449	-162.42	24.041	-68.655	0.3183
2.5000	7.5798	-175.47	9.8079	-160.46	22.297	-96.301	0.3979
3.0000	4.1902	179.06	7.3638	-161.59	19.654	-116.62	0.4775
3.5000	1.2924	174.83	5.1874	-164.87	16.887	-129.94	0.5570
4.0000	-1.2435	171.37	3.1277	-168.32	14.337	-138.65	0.6366
5.0000	-5.5466	165.84	-.59798	-173.98	10.046	-148.83	0.7958
6.0000	-9.1413	161.49	-3.8227	-178.11	6.6134	-154.37	0.9549
7.0000	-12.250	157.95	-6.6394	178.81	3.7790	-157.76	1.1141
8.0000	-15.001	155.02	-9.1327	176.46	1.3726	-160.01	1.2732
10.0000	-19.727	150.58	-13.386	173.27	-2.5536	-162.75	1.5915
12.5000	-24.605	146.95	-17.712	171.03	-6.3660	-164.64	1.9894
16.0000	-30.137	144.22	-22.528	169.63	-10.458	-166.35	2.5465
20.0000	-35.207	143.02	-26.868	169.16	-14.084	-168.14	3.1831
25.0000	-40.294	142.92	-31.181	169.20	-17.734	-170.48	3.9789
30.0000	-44.454	143.41	-34.697	169.41	-20.801	-172.57	4.7746
35.0000	-48.002	143.95	-37.691	169.62	-23.459	-174.20	5.5704
40.0000	-51.169	144.27	-40.341	169.77	-25.795	-175.38	6.3662
50.0000	-57.237	144.17	-45.148	170.46	-29.731	-176.86	7.9577
60.0000	-85.687	156.91	-50.064	178.24	-32.950	-177.70	9.5493
70.0000	-63.607	-144.12	-51.234	-158.40	-35.668	-178.23	11.1408
80.0000	-62.075	-162.17	-51.174	-164.79	-38.019	-178.59	12.7324
100.0000	-65.720	-177.12	-54.725	-174.13	-41.936	-179.03	15.9155

Figure 21. Frequency Response of Transfer Functions.

TRIM SWEEPS

The parameter sweep operation (figure 3) may be used to simulate the stacking of TRIM and TRIM-STAB data decks for a given rotorcraft. Within a sweep deck, the user specifies by input data those cases in the sweep for which a rotorcraft stability analysis is and is not to be performed. The parameters most frequently swept include airspeed, gross weight, center-of-gravity station-line, incidence of an aerodynamic surface, atmospheric conditions, and g-level. Generally, only one parameter is changed from case to case within a single sweep deck. However, any number and combination of inputs except some program logic switches and the values in some data tables may be swept. The assumption is made that each desired trim condition bears some relationship to the previous one, and that the previous trim point is a good starting condition for finding the next trim point. For example, in a speed sweep, a change of 20 or 30 knots is the most that should normally be used between 40 and 150 knots. Outside of this range, the maximum change should not exceed 10 knots.

Following a data set for trim only or trim-and-rotorcraft-stability analysis (NPART = 1 or 7), the parameter sweep option may be exercised by including an NPART = 10 card after the Flight Constants Group (card 234 - labeled with sequence number 1103). An NPART = 10 card permits the changing of user-selected inputs and retrimming the configuration. On the same card, a new input variable is defined (NVARA) which specifies whether a trim or trim-and-rotorcraft-stability analysis is to be performed on this case in the parameter sweep. If NVARA = 0, the program will attempt only to iterate to a new trim condition (equivalent to NPART = 1); if NVARA ≠ 0, the program will attempt to trim and, if successful, will also perform a rotorcraft stability analysis (equivalent to NPART = 7).

The data set for NPART = 10 consists of the following cards:

First Card:	Card 01	NPART card with NPART = 10
Subsequent Card(s):	$Change	Changes to input data using namelist input

An NPART = 10 data set may be followed only by another NPART = 10 data set, and postprocessing program (GDAP80) inputs. Figure 22 shows an example of input data required to perform an airspeed sweep for trim only. Input parameter XFC(1), forward velocity, a parameter in the Flight Constants Group, is changed each time throughout the sweep and the case is retrimmed. The program assumes the last trim point is a good starting point for the next trim case. The reader will note that these NPART = 10 data sets follow immediately behind card 234 of the Flight Constants Group (that card is labeled with a sequence number 00110300 in columns 73-80 of the sample data deck in Appendix A.)

MANEUVER SIMULATION

All maneuvers require a trim point prior to computing the time history of a maneuver. The trim point is used to supply the initial conditions to a system of differential equations that describe the behavior of the rotorcraft in a maneuver. Various external inputs, or forcing functions, may be applied, such as control movements, gusts, store drops, and wing incidence change independent of control motion. At times specified by input data, the maneuver can be suspended while a rotorcraft or rotor aeroelastic stability analysis is performed. The maneuver is then resumed as if no interruption had occurred and continued until it reaches either the next time point to do a stability analysis or the end of the maneuver.

```
                   1.2
         0.0       .0435      0.
         .20       .15        0.0                                          7400
         -.009     .82        .07        0.                             00107500
   0     0.0       0.0        .432658    .220569                        00107600
0.0      0.0       0.0        0.0        0.0       0.0       0.0        00107700
         AH-1G T/H HORIZONTAL STABILIZER GROUP     (OLS CORRELATION)    00107800
7.57     397.5     -18.62     55.66      .697      0.0       16.28      00107900
1.49     .98       .66        0.0        0.0       1.0       0.0        00108000
0.0      0.0       0.0        0.0        0.0       0.0       0.0        00108100
0.0      0.0       0.0        0.0        0.0       0.0       0.0        00108200
         -1.0      -1.0       0.0        0.0       0.0       0.0        00108300
.84      1.25      1.2        0.0        0.0       0.0       1.2        00108400
.087     0.0       .0435      0.0        .008      0.0       .0003284   00108500
.04      .20       .15        0.0        .0332     0.0       0.0        00108600
-.002    -.009     .82        .07        0.0       0.0       0.0        00108700
0.0      0.0       0.0        .432658    .220569   0.0       0.0        00108800
0.0      0.0       0.0        0.0        0.0       0.0       0.0        00108900
         AH-1G CONTROLS GROUP  S/N 20391  (OLS CORRELATION)             00109000
10.0     7.8       19.8                                                 00109100
12.0     -15.6     30.6                                                 00109200
12.0     -11.0     16.87                                                00109300
6.5      10.0      -28.17     0.0        0.0       0.0       0.0        00109400
          ITERATION LIMITS GROUP                                        00109500
41.0     10.0      0.5        0.5        3.0       7.0       .3         00109600
0.2      0.2       1500.      500.       1.0       0.1       2000.      00109700
25.      25.       25.        25.        25.       25.       5.         00109800
         OLS FLIGHT CONSTANTS GROUP                                     00109900
129.3                         1000.0     -1.2      -3.2      -1.232     00110000
35.0     70.0      55.0       50.0                                      00110100
-2.0     -.5       -1.1       1.0        7450.0    -250.0               00110200
                   1250.0     6000.0     -1.0      2900.0    27.0       00110300
10       0                                                              00110400
 $CHANGE XFC(1) = 120.0, $END                                           00110500
10       0                                                              00110600
 $CHANGE XFC(1) = 100.0, $END                                           00110700
10       0                                                              00110800
 $CHANGE XFC(1) = 80.0, $END                                            00110900
10       0                                                              00111000
 $CHANGE XFC(1) = 60.0, $END                                            00111100
```

Parameter Sweep Input Cards;
Forward Velocity Sweep at 129.3,
120.0, 100.0, 80.0, and 60.0 KTS.

Figure 22. Input Data for Parameter Sweep.

A maneuver restart operation is begun just like an ordinary maneuver using a trim condition as a starting point. The only difference is that the time-history variables and many intermediate variables are saved on the restart magnetic tape. Subsequent maneuver restarts use the condition at one of the saved time points as the initial conditions, and so do not require a trim condition or the complete data set defining the rotorcraft.

Figures 4 through 7 illustrate the type of operations that can be performed that are related to maneuver simulation.

Maneuver Simulation Operation	NPART
a) Trim followed by maneuver	2
b) Trim followed by maneuver with rotorcraft stability analysis	2
c) Trim followed by a maneuver in which maneuver time-point data are stored for a subsequent restart of the maneuver	4
d) Maneuver restart	5

An NPART = 2 card specifies the computation of a trimmed flight condition followed by a maneuver. Subject to the Program Logic Group (IPL) values, a data set of cards 02 through 291 (the maneuver time card) plus at least one 301-type card (maneuver specification card or commonly called J-card) must follow. The maneuver start time on card 291 is set to zero regardless of the input value. The postprocessing program (GDAP80) inputs follow the last J-card.

Whenever a maneuver simulation is called for (NPART = 2, 4 or 5) an additional input parameter, NPRINT, which specifies the frequency of printout of maneuver data, is to be supplied in columns 4-6 of the NPART card. The program prints data showing initial conditions for the maneuver (maneuver time t = 0) and for every NPRINTth time point thereafter. A blank or zero input is reset to unity.

An NPART = 4 will do the same as NPART = 2, except that the maneuver data will be stored so that it can be recalled at a later date for a maneuver restart (NPART = 5). The use of this option will require the assistance of the local programmer to set up the restart tape.

For a maneuver restart case (NPART = 5), the maneuver time card has the start time input as the time at which the maneuver is to be restarted. It must be greater than zero and less than the last point of the maneuver being restarted. The time for restart need not be identically equal to a previous time point. Then, at least one maneuver specification (J-card) is required. The inputs to GDAP80 follow these inputs.

Maneuver Time Card and Maneuver Specification Cards

The following information is provided on the maneuver time card (card 291) as input data:

TCI(1)	Start time of maneuver (seconds)
TCI(2)	First time or azimuth increment (seconds or degrees)
TCI(3)	Time to stop using first increment (seconds)
TCI(4)	Second time or azimuth increment (seconds or degrees)
TCI(5)	Time to stop using second increment and return to first increment (seconds)
TCI(6)	Time to stop the maneuver (seconds)

TCI(2) is used to specify the first base value of the time increment (Δt) between the calculation of maneuver time points. The Δt computed from TCI(2) will be used during the interval of TCI(1) to TCI(3) seconds of maneuver time. If TCI(2) $<$ 1.0, the input is taken to be Δt in seconds. If TCI(2) $\geq$ 1.0, the input is taken to be the increment in rotor 1 azimuth location in degrees between time points; in this case, the time increment to be used is defined as

$$\Delta t = \text{TCI}(2) \; / \; 6 \, \Omega_1$$

where Ω_1, is the rotational speed of rotor 1 in units of rpm and Δt is in seconds.

It may be desirable to change the value of Δt because of a change in rotor speed. For this case, TCI(4) can be used to specify the value of Δt to be used between TCI(3) and TCI(5) seconds of maneuver time. Like TCI(2), TCI(4) may be either a time or azimuth increment. It is not necessary that TCI(2) and TCI(4) be the same type of increment; e.g., one may be time and the other azimuth.

If TCI(6), the time to stop the maneuver, is greater than TCI(5), the program then uses the Δt based on TCI(2) between TCI(5) and TCI(6) seconds of maneuver time. If TCI(5) is the time to stop the maneuver, as well as the time to stop using the Δt based on TCI(4), the TCI(6) input may be zero or blank. If a second time increment is not desired, then TCI(4) and TCI(5) should be input as 0.0. In this case, TCI(6) will be ignored and TCI(3) is taken as the time to stop the maneuver.

If NPART = 2, 4, or 5, one maneuver specification card (card 301 or J-card) must be included and up to 20 may be included. All have the same format (I1, I4, 5X, 6F10.0). It is not necessary to have the J values in numerical order, and there may be several cards with the same value of J. It is necessary that "next J" (in col 1) be blank on all of these cards except the last one, which must have some symbol in the first column.

Permissible values of J are from 1 to 45. The type of variation that occurs for each value of J is given in the following list.

J = 1	Movement of collective stick
J = 2	Movement of longitudinal cyclic stick
J = 3	Movement of lateral cyclic stick
J = 4	Movement of pedal
J = 5	Inactive
J = 6	Folding rotors aft after tilting forward and stopping
J = 7	Inactive
J = 8	Inactive
J = 9	A vertical ramp gust; ramp length may be zero
J = 10	A vertical sine-squared gust
J = 11	A horizontal ramp gust; ramp length may be zero
J = 12	A horizontal sine-squared gust
J = 13	A change in engine torque supplied
J = 14	A change in auxiliary thrust supplied
J = 15	Inactive
J = 16	Weapon fire
J = 17	Change of longitudinal mast tilt angle and of RPM on both rotors
J = 18	Rotor brake
J = 19	Inactive
J = 20	Sinusoidal movement of controls or mast
J = 21	Inactive
J = 22	Inactive
J = 23	RPM-dependent hub springs
J = 24	SCAS roll channel
J = 25	SCAS pitch channel
J = 26	SCAS yaw channel
J = 27	Folding rotors horizontally after stop
J = 28	RPM dependent flapping stops
J = 29	Connecting and disconnecting helicopter controls
J = 30	Rotor moment balancing mechanism
J = 31	Changing NPRINT
J = 32	Simplified automatic pilot simulation
J = 33	Inactive
J = 34	Deployment of an aerodynamic brake
J = 35	Dropping an external store
J = 36	Changing incidence or control surface deflection angles of aerodynamic surfaces
J = 37	A trailing vortex system
J = 38	Inactive
J = 39	Inactive
J = 40	Inactive
J = 41	Roll rate input to autopilot (P-Tracker)
J = 42	Pitch rate input to autopilot (Q-Tracker)
J = 43	Yaw rate input to autopilot (R-Tracker)
J = 44	Normal load factor input to autopilot (G-Tracker)
J = 45	Rate-of-climb input to autopilot (RC-Tracker)

The input format for each of the currently available J-cards is given in section 4.29 of reference 1. Start and stop times refer to the time from the start of maneuver unless otherwise noted.

Figure 23 presents a sample input for a maneuver that consists of longitudinal, lateral and pedal doublets input sequentially at maneuver time t = 0.0, 1.0, and 2.0 seconds respectively. The data set required follows immediately behind the flight constants group and in this sample case consists of cards labeled sequentally 1104 through 1110. The maneuver time card (labeled 1104) indicates that the overall maneuver begins at time t = 0.0, ends at time t = 7.5 seconds, and the time increment (Δt) between the calculation of maneuver time points is .02 seconds.

For this sample case the following input format defines the information contained in the six maneuver specification cards (labeled 1105 - 1110) needed to simulate this maneuver.

Col 1	Blank except for last card in group	
Col 2-5	J, = 2 longitudinal, = 3 lateral, = 4 pedal movement	
Col 11-20	Start time for input rate 1	(sec)
Col 21-30	Input rate 1	(in./sec)
Col 31-40	Stop time for input rate 1	(sec)
Col 41-50	Start time for input rate 2	(sec)
Col 51-60	Input rate 2	(in./sec)
Col 61-70	Stop time for input rate 2	(sec)

For normal control rigging, positive control rates correspond to up collective, forward longitudinal cyclic, right lateral cyclic and up rotor 2 collective.

Maneuver Simulation Output

The program prints the contents of the maneuver time card (card 291) and all maneuver control cards (all 301-type cards, the J-cards) before starting the trim procedure (figure 24). A program-supplied title for the action caused by each J-card is included to the left of the numerical inputs of the J-cards. This serves as a record of the type of maneuver specified as well as a quick way to check the input data.

Prior to performing the maneuver, the program will calculate and print out the trim iteration pages, a standard trim page and an optional trim page.

It is possible to print out data computed during a maneuver at specified time points. The value of NPRINT on CARD 01 specifies that data is to be printed each NPRINTth time point. For the sample case that was run, NPRINT = 5 and Δt (time increment between maneuver time point calculations) = .02 seconds. Then, for this case, the maneuver time point data is printed out every .1 second.

The format of and data on the maneuver-time-point page are identical to those of the standard trim page with the following exceptions. The problem identification data, trim condition specification, and atmospheric parameters are omitted; some data in the aerodynamic surfaces printout are changed; and some data are added at the top of the page to the body and ground reference parameters and to the rotor parameter printouts. Figure 25 illustrates a typical maneuver-time-point printout page. The maneuver-time-point page is followed by a force and moment summary in both body axis and wind axis for that time point (figure 26). The format of the summary is identical to the summary printed during trim iterations.

```
                                                                                   7200
                 .0      .0435                                                   107300
                 .20     .15       0.                                          00107400
                 -.009   .82       .07                                         00107500
                 0.0     0.0       .432858    .220569               0.0        00107600
  0.0            0.0     0.0       0.0        0.0        0.0        0.0        00107700
        AH-1G L/H HORIZONTAL STABILIZER GROUP   (OLS CORRELATION)              00107800
  7.57           397.5   -18.62    55.66      .697       0.0        16.28      00107900
  1.49           .98     .66       0.0        0.0        1.0        0.0        00108000
  0.0            0.0     0.0       0.0        0.0        0.0        0.0        00108100
  0.0            0.0     0.0       0.0        0.0        0.0        0.0        00108200
                 -1.0    -1.0      0.0        0.0        0.0        0.0        00108300
  .84            1.25    1.2       0.0        0.0        0.0        1.2        00108400
  .087           0.0     .0435     0.0        .008       0.0        .0003284   00108500
  .04            .20     .15       0.0        .0332      0.0        0.0        00108600
  -.002          -.009   .82       .07        0.0        0.0        0.0        00108700
  0.0            0.0     0.0       .432858    .220569    0.0        0.0        00108800
  0.0            0.0     0.0       0.0        0.0        0.0        0.0        00108900
        AH-1G CONTROLS GROUP  S/N 20391  (OLS CORRELATION)                     00109000
  10.0           7.8     19.8                                                  00109100
  12.0           -15.6   30.6                                                  00109200
  12.0           -11.0   16.87                                                 00109300
  6.5            10.0    -28.17    0.0        0.0        0.0        0.0        00109400
         ITERATION LIMITS GROUP                                                00109500
  41.0           10.0    0.5       0.5        3.0        7.0        .3         00109600
  0.2            0.2     1500.     500.       1.0        0.1        2000.      00109700
  25.            25.     25.       25.        25.        25.        5.         00109800
        OLS FLIGHT CONSTANTS GROUP                                             00109900
  129.3                            1000.0     -1.2       -3.2       -1.232     00110000
  35.0           70.0    55.0      50.0                                        00110100
  -2.0           -.5     -1.1      1.0        7450.0     -250.0                00110200
                         1250.0    6600.0     -1.0       2900.0     27.0       00110300
  0.0            0.02    7.5                                                   00110400  Maneuver Time Card
       2         0.0     10.0      0.1        0.4        -10.0      0.6        00110500
       2         0.9     10.0      1.0        1.0        0.0        7.5        00110600  Maneuver
       3         1.0     -10.0     1.1        1.4        10.0       1.6        00110700  Specification
       3         1.9     -10.0     2.0        2.0        0.0        7.5        00110800  Cards
       4         2.0     -5.0      2.1        2.4        5.0        2.6        00110900
  /    4         2.9     -5.0      3.0        3.0        0.0        7.5        00111000
```

Figure 23. Maneuver Simulation Input Data.

INPUT DATA FOR MANEUVER

START (SEC)	DELT1 (SEC)	MAX1 (SEC)	DELT2 (SEC)	MAX2 (SEC)	MAX3 (SEC)
0.000000	.020000	7.500000	.020000	0.000000	0.000000

	J	XCIT(J,1)	(J,2)	(J,3)	(J,4)	(J,5)	(J,6)
F/A CYCLIC STICK	2	0.000	10.000	.100	.400	-10.000	.600
F/A CYCLIC STICK	2	.900	10.000	1.000	1.000	0.000	7.500
LATERAL CYCLIC STICK	3	1.000	-10.000	1.100	1.400	10.000	1.600
LATERAL CYCLIC STICK	3	1.900	-10.000	2.000	2.000	0.000	7.500
PEDAL MOVEMENT	4	2.000	-5.000	2.100	2.400	5.000	2.600
PEDAL MOVEMENT	4	2.900	-5.000	3.000	3.000	0.000	7.500

Figure 24. Maneuver Specification Printed as Output

```
      1.500   SECONDS MANEUVER TIME            1.558   MINUTES ELAPSED COMPUTING TIME

----WEIGHTS-----   CENTER OF GRAVITY (IN)     -----------POWER/TORQUE-----------   -----------BLADE-----------   -JET THRUST-
      POUNDS       S.L.     B.L.     W.L.               SHAFT     TORQUE   SPEED      TIP   ADV BLD   INERTIA         LBS
BASIC A/C  8319.   200.60   0.00     68.00          HORSEPOWER    FT-LB    RPM      SPEED  MACH NO  SLUG-FT-SQ
STORES        0.                                MAIN    660.42   10703.6   324.1    747.     .846   1503.394     RT       0.0
TOTAL      8319.   200.60   0.00     68.00      TAIL     28.24      89.5  1656.6    737.     .838      1.532     LT       0.0
                                                ENG     686.67   11161.4  6600.0
                                                REQD    666.67   11161.4

                                      BODY REFERENCE                                      GUSTS AT CG (FT/SEC)
                 U          V          W          P          Q          R        BOBWT     FWD    0.00
     VELOCITY  218.324     3.558    -12.330     -6.203      1.572      -.363     0.000     LAT    0.00
     ACCEL.       .751     3.372      6.550      4.456     -1.943     -2.972     0.000     VERT   0.00

------FLIGHT PATH CONDITION-------    ------------------------------AERODYNAMIC SURFACES------------------------------
TRUE AIRSPEED     (KNOTS)   129.58              ANGLE OF    FLAP     ------WIND AXIS COEF------    AERODYNAMIC ANGLE
GROUND SPEED      (KNOTS)   129.57    SURFACE   INCIDENCE   ANGLE     CL        CD        CM       ATTACK  SIDESLIP
RATE OF CLIMB    (FT/SEC)   -2.00     NO. 1       4.50      0.00     .1341     .0119    -.0018     3.59    -3.05
CLIMB ANGLE         (DEG)    -.52     NO. 2       2.77      0.00    -.0376     .0084     .0455    -1.10      .99
HEADING ANGLE       (DEG)     .35
ANGLE OF ATTACK     (DEG)   -3.23     NO. 3       2.77      0.00    -.0343     .0084     .0454    -1.02      .99
ANGLE OF SIDESLIP   (DEG)     .93     NO. 4       0.00      0.00    0.0000    0.0000    0.0000     0.00     0.00
ANGLE OF AERO YAW   (DEG)    -.93
ACCELERATIONS  VERT   (G)     .99     RT WING    14.00      0.00     .7088     .0706    0.0000    10.83     1.11
               FWD    (G)     .05     LT WING    14.00      0.00     .6975     .0693    0.0000    10.72      .75
               LAT    (G)    -.02

                                    GROUND REFERENCE
                    EULER ANGLES TO BODY REFERENCE       DISPLACEMENTS
                      PSI       THETA      PHI         X          Y          Z
          VELOCITY   -.369      1.571    -6.178     218.687     1.339      1.998    DISTANCE    327.7
          LOCATION   -.570     -3.759     -.206     327.685      .943   -998.048    ALTITUDE    998.0

CONTROL DISPLACEMENTS   -------------SWASH PLATE ANGLE (DEGREES)-------------   --HUB-MAST-PYLON---------(MAIN)---(TAIL)-
     ---PERCENT---      -------MAIN ROTOR-------   --------TAIL ROTOR-------   DELTA 3         (DEG)        0.0     45.0
                          COLL    F/A     LAT       COLL    F/A     LAT        PHASING         (DEG)        0.00    0.00
COLL       (UP)   38.53   15.43   0.00    0.00      0.00    0.00    0.00       HUB SPRING MOMENT F/A        -0.      0.
F/A CYC   (FWD)   68.62    0.00   5.40    0.00      0.00    0.00    0.00                  (FT-LB) LAT        0.      0.
LAT CYC    (RT)   55.62    0.00   0.00   -1.62      0.00    0.00    0.00       PYLON ANGLES       F/A       0.00    0.00
PEDAL      (LT)   47.57    0.00   0.00    0.00     -3.40    0.00    0.00                    (DEG) LAT       0.00    0.00
SUM OF PYLON AND SCAS      0.00   0.00    0.00      0.00    0.00    0.00       MAST ANGLE (DEG)   F/A       0.00    0.00
TOTAL SWASH PLATE ANG     15.43   5.40   -1.62     -3.40    0.00    0.00                          LAT       0.00  -90.00

-------------------------------------------------------ROTORS---------------------------------------------------------
       BLADE FEATHERING - DEG     FLAPPING - DEG     FORCES (SHAFT AXIS) POUNDS     ADVANCE    CP       CT      INDUCED
       MEAN    PSI=0   PSI=90      F/A      LAT      THRUST    H-FORCE   Y-FORCE     RATIO    X105     X104    VELOCITY
MAIN   15.43    1.62    -5.40    -2.326    -.516     7387.77   -133.31   -151.75      .292   27.954   42.447     6.07
TAIL   -3.40   -1.47      .72    -1.467     .716     -271.99     20.52     -3.30      .296   33.262  -42.937    -6.00

                     BETA                   SHAFT AXIS DATA AT ROTOR HUB                  HUB MOTION (FT)         MAST
     PSI (DEG)    HUB    LIMIT     VELOCITIES (FT/SEC)      SHEAR FORCES (POUNDS)                                WIND-UP
                 (DEG)   (DEG)      U        V        W        X        Y        Z         X       Y       Z      (DEG)
MAIN   36.54     -.11    12.00    218.13    2.79   -12.33    408.4   -254.2  -5971.2    0.000   0.000   0.000    0.000
TAIL  149.40     -.35    11.00    218.22  -11.73     2.56    -21.4       .4    278.1    0.000   0.000   0.000    0.000
```

Figure 25. Maneuver-Time-Point Printout Page.

FORCE AND MOMENT SUMMARY

BODY AXIS	X-FORCE	Y-FORCE	Z-FORCE	ROLL	PITCH	YAW
FUSELAGE	-376.8	-40.0	70.3	-153.3	-1200.6	-865.2
MAIN ROTOR	133.3	-151.7	-7387.8	-1071.8	-572.2	-7.6
TAIL ROTOR	-20.5	272.0	-3.3	1135.5	-2.0	-7230.5
RIGHT WING	-75.9	-30.2	-485.6	-1155.2	441.6	153.1
LEFT WING	-75.4	25.3	-478.0	1137.0	434.7	-156.3
STABILIZER #1	-13.0	-124.0	1.0	301.2	56.7	-3110.7
STABILIZER #2	-2.2	-.1	14.2	21.4	268.5	4.4
STABILIZER #3	-2.3	-.1	12.9	-20.7	248.0	-2.5
GROSS WEIGHT	545.4	-29.8	8301.0			
M.R. TORQUE				.0	-.0	10703.6
T.R. TORQUE				0.0	-89.5	-.0
TOTAL	112.6	169.4	44.9	194.1	-414.8	-511.8

FORCE AND MOMENT SUMMARY

WIND AXIS	DRAG(AFT) FORCE	SIDE FORCE	LIFT(UP) FORCE	ROLL MOMENT	PITCH MOMENT	YAW MOMENT
FUSELAGE	380.8	-33.8	-49.0	-123.8	-1198.7	-872.5
MAIN ROTOR	-547.1	-160.7	7368.5	-1078.9	-554.7	-68.0
TAIL ROTOR	15.9	272.3	4.4	1541.2	-27.1	-7155.0
RIGHT WING	48.9	-29.4	489.1	-1154.6	460.5	87.7
LEFT WING	47.9	26.1	481.5	1150.9	416.0	-92.0
STABILIZER #1	11.0	124.2	-.3	477.0	49.0	-3088.8
STABILIZER #2	3.0	-.0	-14.0	25.5	268.1	5.6
STABILIZER #3	3.0	-.0	-12.8	-16.4	248.3	-3.7
GROSS WEIGHT	-76.0	-31.0	-8318.6			
M.R. TORQUE				603.5	9.8	-10686.6
T.R. TORQUE				-1.5	-89.5	-.0
TOTAL	-112.7	167.6	-51.1	215.8	-418.4	-500.1

Figure 26. Maneuver-Time-Point Force and Moment Summary.

Figure 27 illustrates for the sample case a time history of the sequential doublet control inputs and the resulting aircraft attitudes and rates in all three axes. This time history was produced by hand plotting the data from each of the maneuver-time-point printout pages that were computed for this case. It will be shown later in the description of the postprocessing program, GDAP80, that this data can be plotted automatically by the computer.

RETRIEVING MANEUVER TIME-HISTORY DATA STORED ON MAGNETIC TAPE

A small portion of AGAP80 is invoked to read a maneuver data tape that had been created during a previous maneuver simulation. The data read from the tape is transferred to a disk file for subsequent postprocessing by the postprocessing program, GDAP80.

An NPART = 8 card causes data stored on tape to be loaded on the plot disk (see figure 8). The local programmer should be consulted prior to its use. The value of NVARA on this card must not be equal to zero. The three comment cards (cards 02, 03, and 04) and the GDAP80 inputs constitute the remainder of the NPART = 8 deck. Comment card no. 1 (card 02) has a numeric title for the data set for identification purposes. It is printed in the output heading and is titled IPSN. Note that the IPSN in columns 4-10 of card 02 must be identical to the IPSN used in the run which created the tape.

GDAP80 OPERATIONS

During the course of running a trim or maneuver, the values of a large number of time-history variables at each time point are saved on the plot disk. At the conclusion of the trim or maneuver, postprocessing operations specified in the GDAP80 input data are performed on these variables. Eight postprocessing operations can be performed on data created by AGAP80, as outlined in figure 28.

A brief explanation of each of these postprocessing capabilities is given in the following sections. At present (time-history plots and storing time-history data on tape) are planned to be utilized by this group but many of the others are considered valuable analysis tools for rotary wing performance and structural analysis personnel.

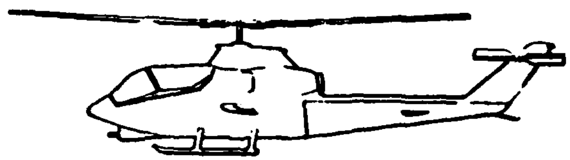
TIME-HISTORY PLOTS (FIGURE 29)

The user may request time-history plots of any of the variables saved during trim or maneuver simulations. Section 9 of reference 1 provides a table of over 2300 variables whose values are saved at each time point during a maneuver simulation. Code numbers are used to identify the variables to be plotted. The code number for each variable saved is given in table 27 of reference 1. These plots may be output on the printer, a CALCOMP drum plotter, or both. Plots created as part of a maneuver restart run will contain data for the entire maneuver.

AEROELASTIC STABILITY ANALYSES (FIGURES 30 AND 31)

Program GDAP80 contains two analyses capable of identifying the frequency and damping of a perturbed multi-variable system. The user can select either the Moving Block Fast Fourier Transform Analysis (NPART = 6) or the Prony Analysis (NPART = 13) to examine the nonsteady-state response of either rotor. See sections 12.3 and 12.4 of reference 3, Volume I - Engineer's Manual for an understanding of these two analyses. The

C-81 MODEL OF



A/C: AH-1G
WT=8319 LB
AFT C.G.
V=129.3 KT
ALT=4927 HD
SCAS OFF

CONTROL INPUT:
SEQUENTIAL
DOUBLETS
(DB, DA, DP)

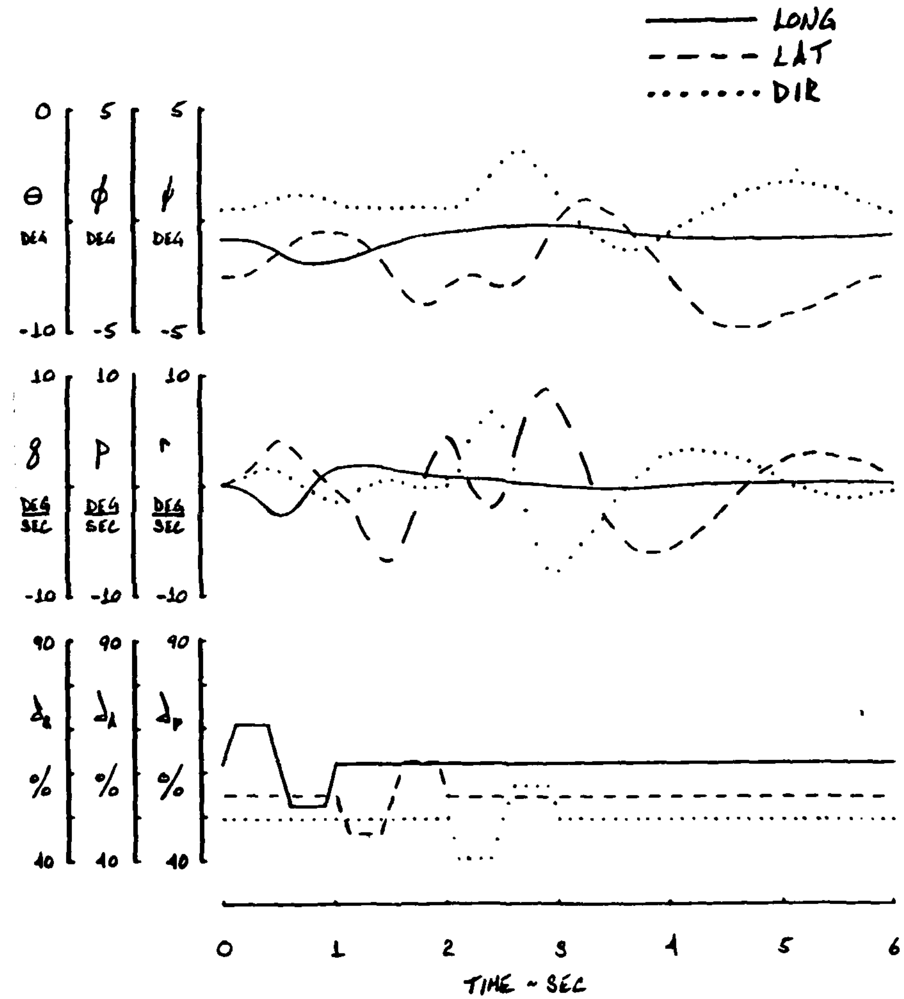


Figure 27. Sample Time-History of Maneuver Simulation.

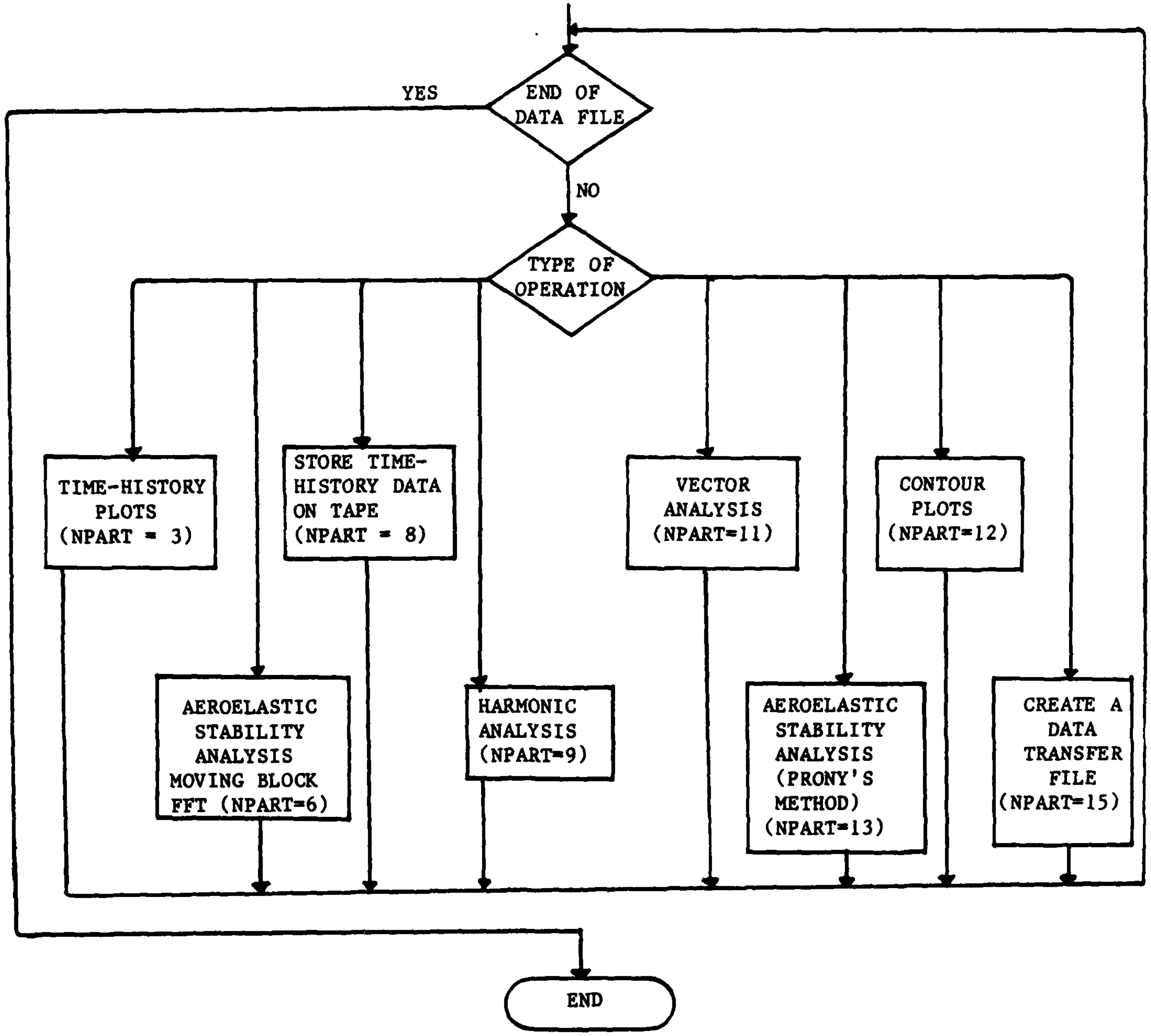


Figure 28. GDAP80 Postprocessing Operations - Performed on Time-History Data Created by AGAP80

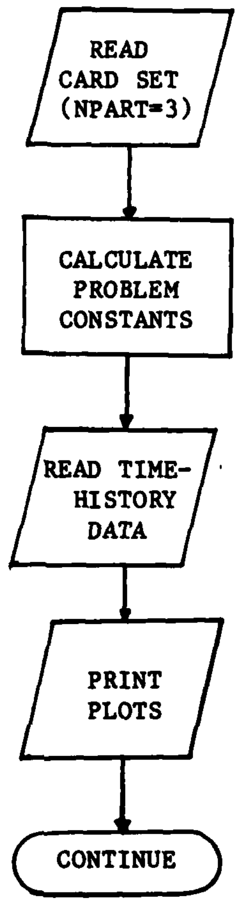


Figure 29. Plotting Operation.

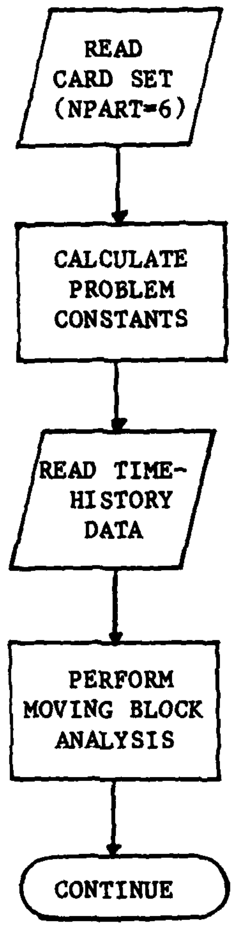


Figure 30. Moving Block Fast-Fourier Transform Operation.

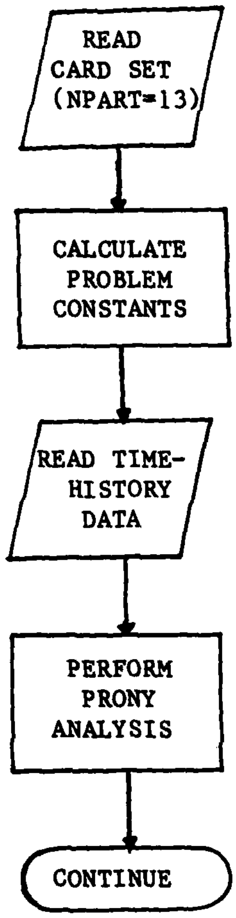


Figure 31. Prony Stability Analysis Operation.

frequency and damping characteristics of airframe motion may also be investigated using these analyses, but that is not their primary function.

STORING TIME-HISTORY DATA ON TAPE (FIGURE 32)

If it is desired to perform additional postprocessing of the saved variables, they may be transferred from the plot disk to a magnetic time-history tape (NPART = 8). The data on the tape may then be reloaded to the plot disk for further use at a later time. Note that time-history data which has been stored on tape can be retrieved with an AGAP80 deck with NPART = 8.

HARMONIC ANALYSIS (FIGURE 33)

A complete harmonic analysis may also be made for any of the saved variables (NPART = 9). A Fast-Fourier-Transform technique is used to examine a broad range of frequencies. This option is especially useful for studying rotor bending moments and related variables.

VECTOR ANALYSIS (FIGURE 34)

Frequently, maneuvers are run where one of the controls or the longitudinal mast tilt angle is varied sinusoidally. In this case, the vector analysis operation (NPART = 11) can be very useful. This analysis uses the least-squared-errors technique to fit the saved data to a curve of the form

$$F_i(t) = A_i \mathrm{SIN}(\omega t + \phi_i) + B_i$$

Then, any amplitude ratios, A_i/A_j, and phase angle differences, $\phi_i - \phi_j$, may be computed. Lastly, linear combinations of the variables may be derived in the following form:

$$F_i(t) = C_i F_j(t) + D_i F_k(t) + E_i$$

CONTOUR PLOTS (FIGURE 35)

Rotor aerodynamic quantities can be tabulated versus radial station and azimuth and plotted in plane-polar format using this option (NPART = 12). The data are plotted assuming that the blade stations are equally spaced along the radius. The tabulations and plots are particularly useful for displaying the rotor aerodynamic environment.

CREATING A DATA TRANSFER FILE (FIGURE 36)

This option permits the user to transmit C81-generated data to a temporary file accessed by the DATAMAP File Creation program in order to add the data to the DATAMAP Master File (NPART = 15). The user can then use DATAMAP to postprocess the C81 data and compare it with test data also resident upon the Master File. (The DATAMAP programs are described in detail in reference 4). Note that this option is described here to demonstrate a potential program capability. This installation does not presently have the DATAMAP programs installed.

USER'S GUIDE TO THE INPUT AND OUTPUT FOR GDAP80

Data generated by AGAP80 can be postprocessed using program GDAP80, which is automatically invoked following an AGAP80 run. All inputs to GDAP80 must follow all inputs to AGAP80. Data to be postprocessed must have been generated by the AGAP80 run.

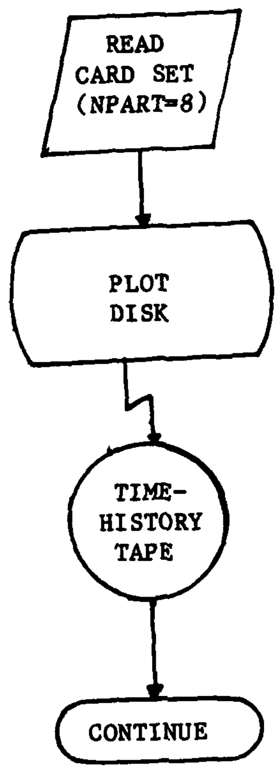


Figure 32. Operation for Storing Maneuver Time-History Data on Tape.

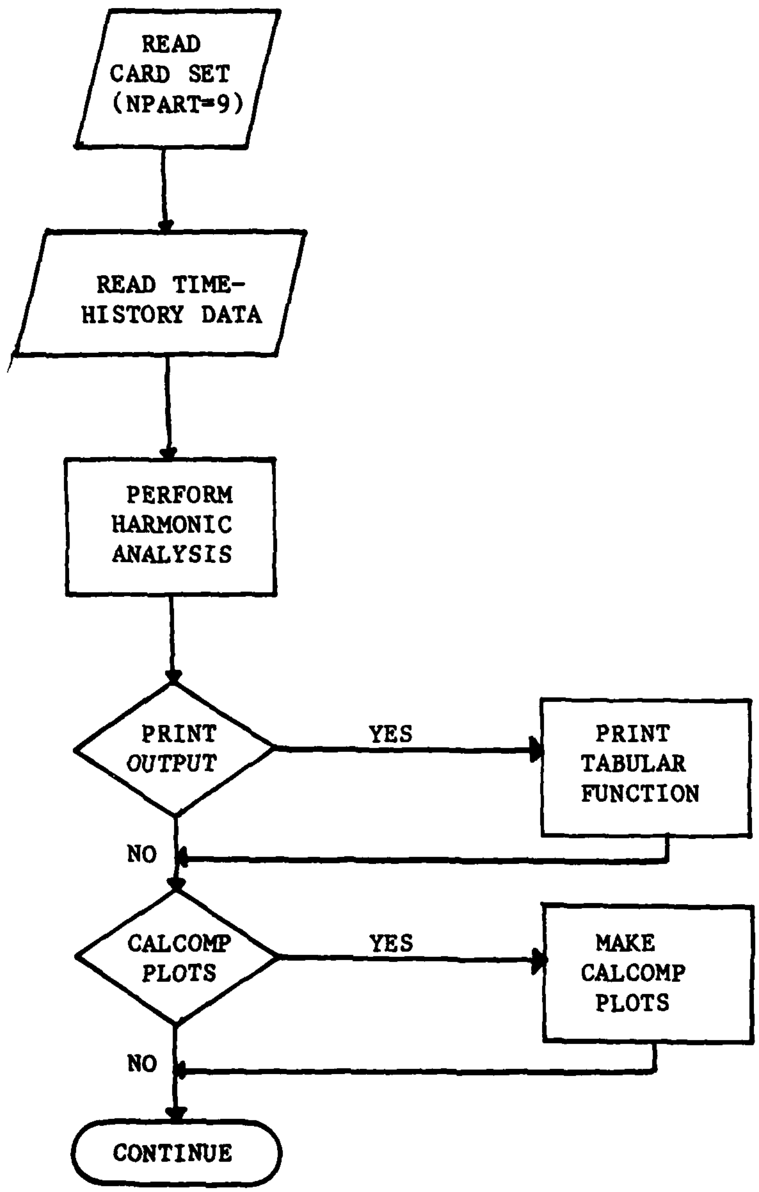


Figure 33. Harmonic Analysis Operation.

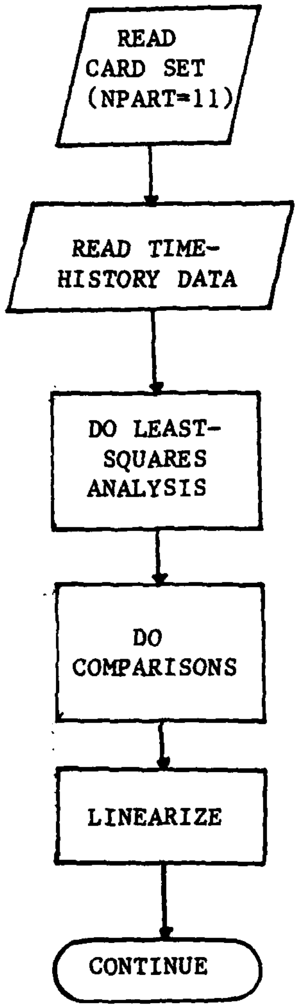


Figure 34. Vector Analysis and Data Reduction Operation.

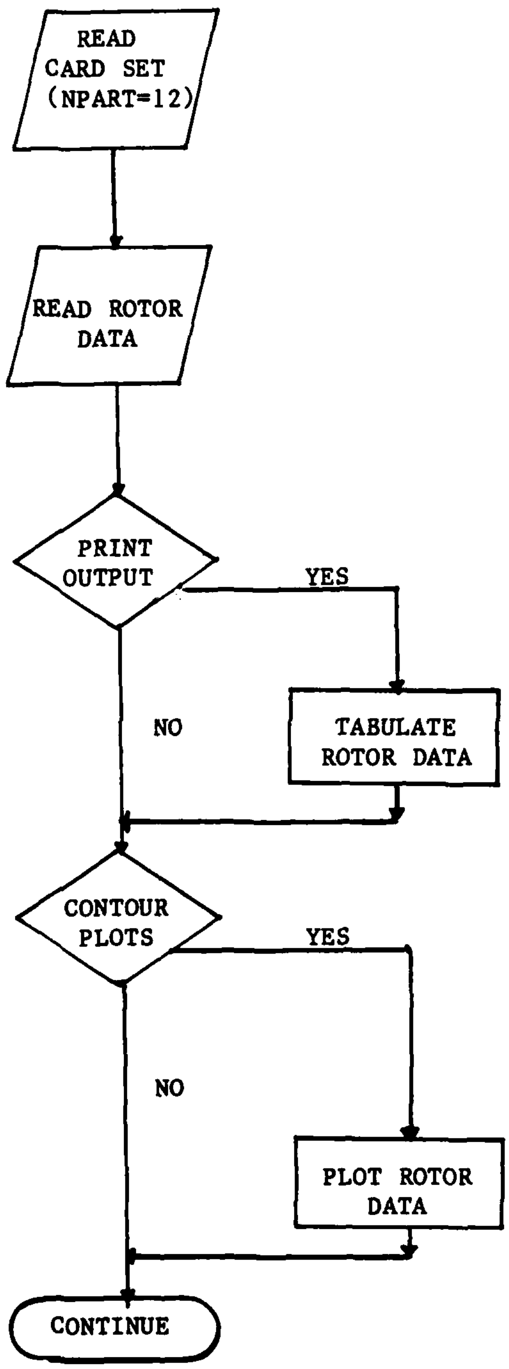


Figure 35. Contour Plot Operation.

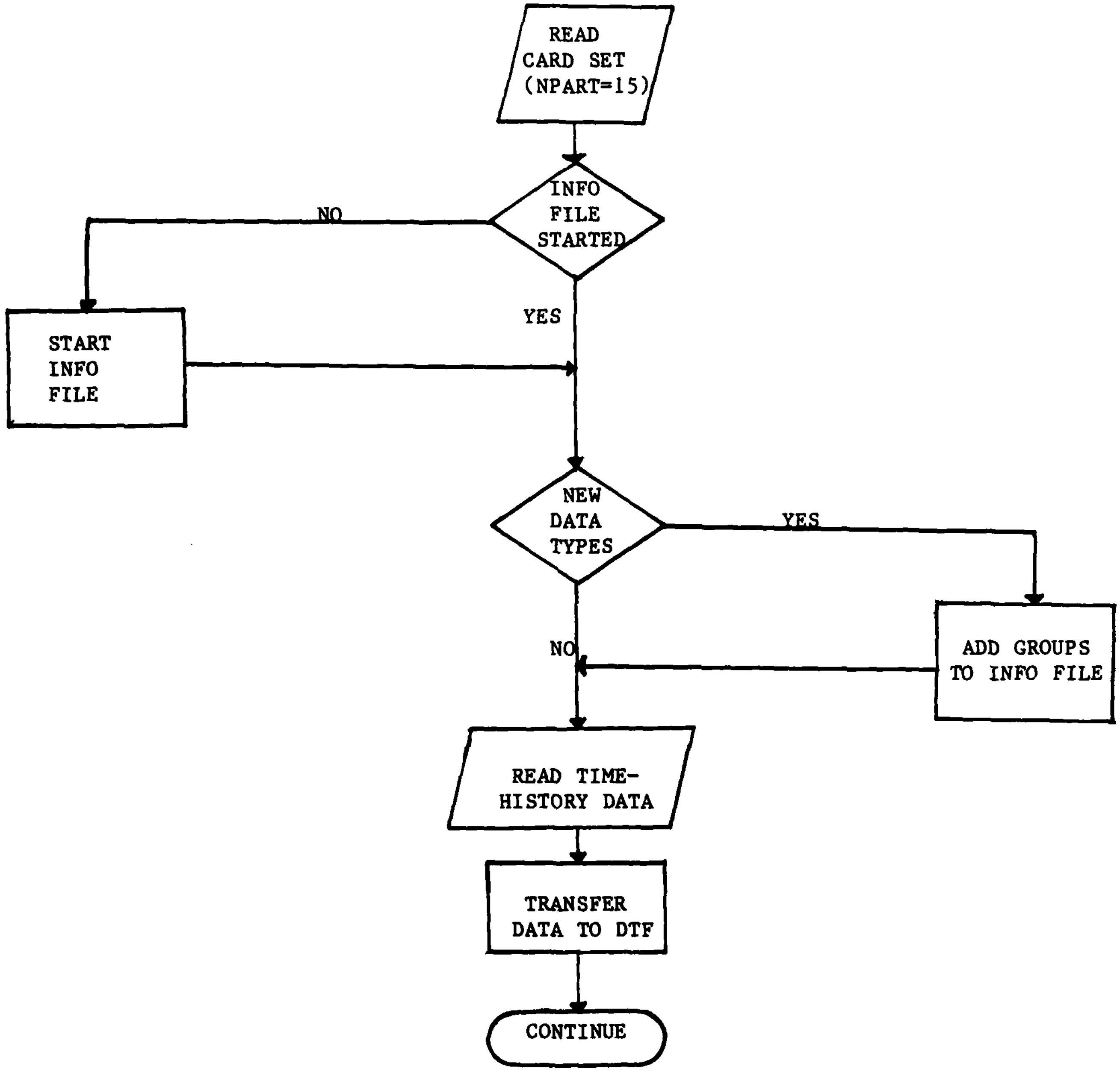


Figure 36. Creation of a Data Transfer File.

The data to be postprocessed by GDAP80 have been stored in one or more Postprocessing Data Blocks (PDB) as they were created by AGAP80. Separate PDBs are created from one of three sources:

1) a Quasi-Static trim for which IPL(79) ≠ 0

2) a Time-Variant trim of either rotor

3) a maneuver

Note that IPL(79) controls the storing of certain Quasi-Static trim rotor variables for tabulation and contour plots. Data are stored in one Postprocessing Data Block for each rotor during Quasi-Static trim whenever IPL (79) ≠ 0.

Since the data in any one PDB is generally completely independant of the data in any other PDB, the postprocessing instructions for a particular PDB are input to GDAP80 in a unique set. Each such set can contain instructions to perform any of the following operations, with certain restrictions:

1) Plot time histories of selected data (NPART = 3)

2) Perform a stability analysis of time-history data using the Moving Block Fast Fourier Transform procedure (NPART = 6)

3) Store maneuver time-history data on magnetic tape for future postprocessing (NPART = 8)

4) Perform an harmonic analysis of time-history data (NPART = 9)

5) Perform a vector analysis of time-history data (NPART = 11)

6) Tabulate or contour plot rotor aerodynamic data (NPART = 12)

7) Perform a stability analysis of time-history data using Prony's Method (NPART = 13)

8) Create a Data Transfer File (NPART = 15)

The NPART = 14 card is used to terminate the list of postprocessing instructions pertaining to a particular PDB. Upon reading an NPART = 14 card, GDAP80 indexes the AGAP80-generated file of data to the beginning of the next PDB and prepares to execute the next set of postprocessing instructions.

As mentioned earlier, only two of these eight postprocessing operations, time-history plots and storing time-history data on tape, are planned at present to be utilized by this group. The input format and output for these two operations is discussed in the following two sections.

PLOTTING OF TIME-HISTORY DATA

The input format for plotting of time-history data is illustrated below.

Card 11

Col	1 - 2	NPART (must equal 14 to move to the next Postprocessing Data Block)

Card 21

Col	2	NPART (must equal 3 for plotting)
Col	4 - 6	NPRINT print control

Cards 22A, 22B... (One for each set of plots desired - 10 maximum)

Col	1	KEYS (Blank except for the last 22-type card)
Col	2 - 5	KV1, Code for variable 1
Col	7 - 10	KV2, Code for variable 2
Col	12 - 15	KV3, Code for variable 3
Col	20	KEY (1 = Plot on printer only)
Col	31 - 40	SC1, Minimum scale for KV1
Col	41 - 50	SC2, Minimum scale for KV2
Col	51 - 60	SC3, Minimum scale for KV3

Section 9 of reference 1 provides a table of the code numbers to be used for KV1, KV2, and KV3.

Whenever time-history data are available, the 20-series cards may be used to plot the data. This procedure is an option. If it is not to be used, simply omit the 20-series cards. The data may be plotted on the computer printer or put on tape for plotting by the CALCOMP plotter. The local programmer should be consulted for the proper setup for jobs that write a tape for CALCOMP plotting.

Time-history data are stored after all time-variant trim cases and for maneuvers and may be plotted by inserting 20-type cards in the data deck. If a maneuver simulation is being performed, a 21-type card and up to 10 22-type cards are placed immediately after the maneuver specification cards. See figure 37, cards labeled with sequence numbers 1111 through 1117, for illustration.

Card 21

Column 2 must contain the integer 3 to call the plotting routine. NPRINT specifies that the first and every NPRINTth data point following are to be plotted. If NPRINT = 0, it is reset to unity.

Cards 22A, 22B, etc.

The first column of all but the last 22-type card must be blank. The first column of the last 22-type card must contain a character (a slash is recommended).

One 22-type card is required for each plot. A maximum of 10 of these cards is permitted after each CARD 21. Each plot may contain one to three variables. The first three inputs (KV1, KV2, KV3) on a 22-type card are the code numbers for the variable(s) to be plotted. The code numbers must be integers. If only one variable is to be plotted. The code numbers must be in columns 2 - 5; if only two are to be plotted, only columns 2 - 5 and 7 - 10 are to be used.

KEY (column 20) controls where the plotting is done.

```
                                                                                  .0
                     .0435                                                       500
           .20       .15       0.0                                           108600
           -.009     .82       .07       0.                                00108700
           0.0       0.0       .432858   .220569   ...       ...           00108800
           0.0       0.0       0.0       0.0       0.0       0.0           00108900
           AH-1G CONTROLS GROUP  S/N 20391  (OLS CORRELATION)              00109000
10.0       7.8       19.8                                                  00109100
12.0       -15.6     30.6                                                  00109200
12.0       -11.0     16.87                                                 00109300
6.5        10.0      -28.17    0.0       0.0       0.0       0.0           00109400
            ITERATION LIMITS GROUP                                         00109500
41.0       10.0      0.5       0.5       3.0       7.0       .3            00109600
0.2        0.2       1500.     500.      1.0       0.1       2000.         00109700
25.        25.       25.       25.       25.       25.       5.            00109800
           OLS FLIGHT CONSTANTS GROUP                                      00109900
129.3                          1000.0    -1.2      -3.2      -1.232        00110000
35.0       70.0      55.0      50.0                                        00110100
-2.0       -.5       -1.1      1.0       7450.0    -250.0                  00110200
                     1250.0    6600.0    -1.0      2900.0    27.0          00110300
0.0        0.02      7.5                                                   00110400- Maneuver Time Card
    2      0.0       10.0      0.1       0.4       -10.0     0.6           00110500 }
    2      0.9       10.0      1.0       1.0       0.0       7.5           00110600 }
    3      1.0       -10.0     1.1       1.4       10.0      1.6           00110700 } Maneuver
    3      1.9       -10.0     2.0       2.0       0.0       7.5           00110800 } Specification
    4      2.0       -5.0      2.1       2.4       5.0       2.6           00110900 } Cards
/   4      2.9       -5.0      3.0       3.0       0.0       7.5           00111000 }
 3   5                                                                     00111100- Card 21
  253   262   244    1         10.0      10.0      10.0                    00111200 }
  271   200   175    1         10.0      2.0       2.0                     00111300 } Plotting
  234   235   233    1         2.0       2.0       2.0                     00111400 } of Time-
  160   161   162    1         2.0       2.0       2.0                     00111500 } History
  168   169   170    1         5.0       5.0       5.0                     00111600 } Data
/ 209   173   239    1         0.2       5.0       100.0                   00111700 }
```

Figure 37. GDAP80 Input Data for Plotting of Time-History Data.

KEY = 0 for CALCOMP only
KEY = 1 for printer only
KEY = 2 for both

The program internally computes its own scales for plotting each variable based on the maximum and minimum values of the variables during the time-history and internally specified minimum scales. The internal minimum scale may be overriden for each variable with the last three inputs on the 22-type card. The minimum scale inputs (SC1, SC2, SC3) are in units of the appropriate variable per inch for printer plots and units per centimeter for CALCOMP plots.

If the user wishes to plot more variables than permitted on the 22-type cards, then another 21-type card should be inserted in the instruction set, followed by up to 10 more 22-type cards.

A sample time-history printer plot that was generated after maneuver simulation is provided in figure 38. The plot symbols used are the numbers 1, 2, and 4. The variables corresponding to each symbol and its units are printed as part of the plot heading. If two or all three of the curves intersect at a single point, the symbol printed is the sum of the individual symbols. For example, the symbol 7 (=1+2+4) means that all three curves pass through the point where the 7 is printed.

The lower and upper limits on the plot scale are given for each variable plotted. The scale in units per inch is also given.

The user is cautioned that the automatic plot scaling procedure may expand small variations completely out of proportion to their true importance. Be certain to check the scales on all plots.

Time is the independent variable, and is printed along the left edge of the plot, defining the time axis. Maneuver plots will always start at t = 0.0. If the time increment is changed at some point during a maneuver, there will be a change in the time scale at this point. The resulting compression or expansion of the time scale may cause apparent discontinuities that are not actually in the data. The user should check the time scale carefully.

Each plot card, CARD 22, is independent of all other plot cards. Thus, if desired, one variable may be plotted on more than one plot.

The dots printed down the page are spaced at 1-inch intervals to make it easier to read the plot values by eye. They also provide reference lines to help see slower variations on long time histories.

The plot routine can store the values of all plot variables for a maximum of 2000 time points. Should the user specify NPRINT = 1 on CARD 21 for a particularly long maneuver, the program will keep internally doubling NPRINT until the total number of points to be plotted is less than or equal to 2000.

For CALCOMP plots, the names of the variables plotted appear at the top of each CALCOMP page along with their respective plot symbols. The vertical scales and the plots themselves are identified by the plot symbols.

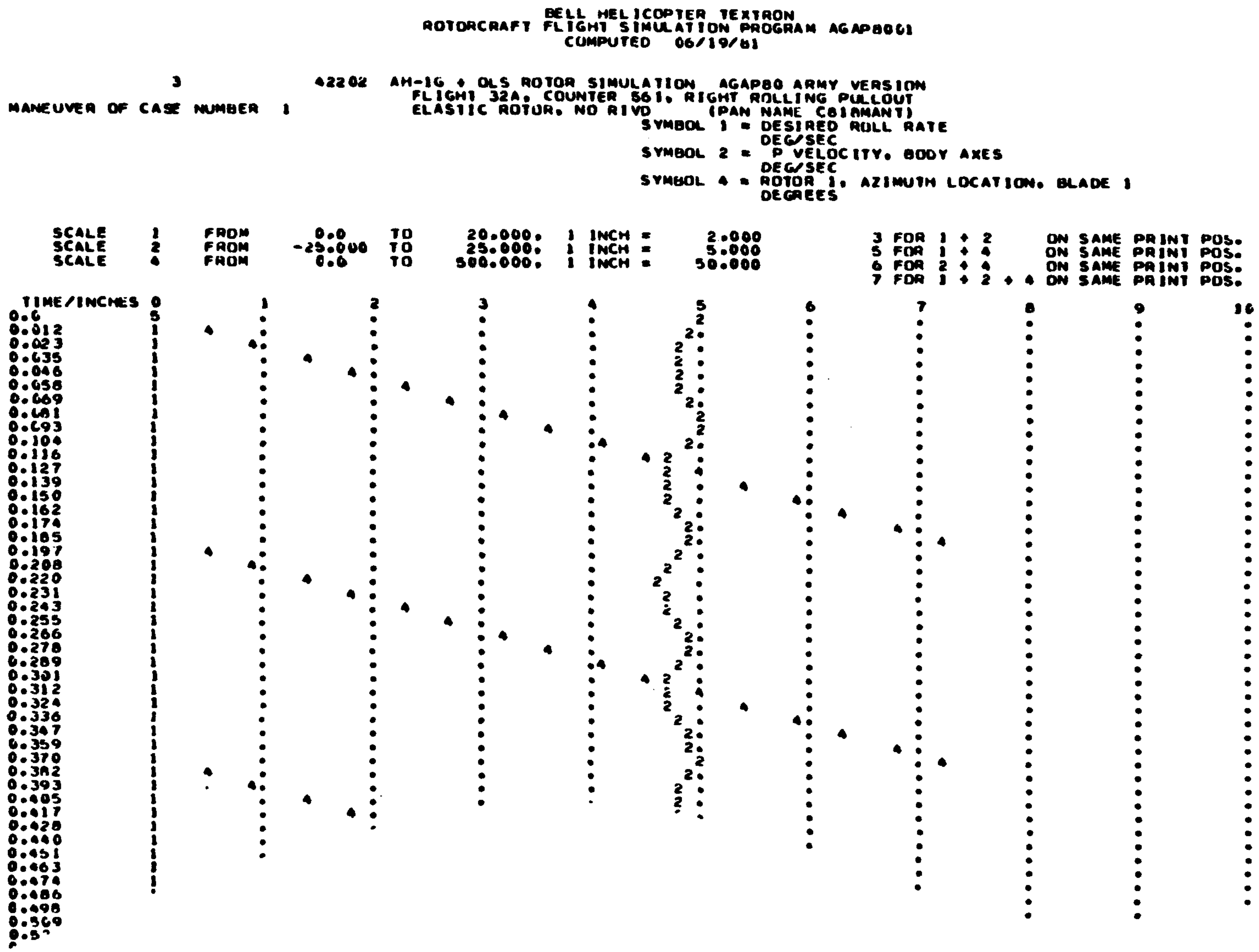


Figure 38. Sample Time-History Plot after Maneuver.

It is recommended that the user avoid plotting periodic variables of approximately the same magnitude, with near-zero phase shifts, on the same plot, as it will be difficult to differentiate between the traces. This applies to printer plots as well. A maximum of 2500 time points may be plotted on CALCOMP PLOTS.

STORING TIME-HISTORY DATA ON TAPE

The input format for this postprocessing option is given below.

Card 41

Note that this card may be included only for the Postprocessing Data Block resulting from a maneuver.

Col 2 NPART (must equal 8 for tape file operations)

Col 11- 15 NVARA (must be blank or all zeros to store data)

Note also that time-history data which has been stored on tape can be retrieved with an AGAP80 deck with NPART = 8.

Following a maneuver (NPART = 2, 4, or 5), it may be desirable to store the time-history on tape so that the data can be recalled later for additional analysis or plotting. Inputs of 8 and 0 in columns 2 and 15 respectively will store the data. However, the local programmer should be consulted for the proper setup of the job before attempting to use this option. This instruction should only be used for the PDB resulting from the maneuver portion of a run.

PRESENT OPERATIONAL PROBLEMS

Two program operation problems were identified while running test cases to check out each of the program operational capabilities. The two problems encountered were 1) the inability to perform any of the postprocessing operations of GDAP80, and 2) the inability to compute the correct eigenvalues in the rotorcraft stability analysis. Both of these problems are associated with the copy of the AGAP80 version that is installed on the CDC CYBER 175/CDC 6600 computer system at NAVAIRDEVCEN and are not considered universal problems with the C81 program.

POSTPROCESSING OPERATIONS

After running a test case to perform a maneuver simulation, it was decided to check out the postprocessing capabilities available in GDAP80, namely, the plotting of time-history data. Upon submitting the test case with all the proper required inputs to plot the time-history of the selected parameters (as indicated in figure 37), the program calculated and printed out all the maneuver-time-point digital data but did not print the printer plots as directed. After investigating the problem it was determined that the CDC conversion copy of the AGAP80 version of C81 as delivered to NAVAIRDEVCEN did not have the postprocessing program (GDAP80) subroutines. Further checking with the Army Structures Laboratory revealed that the postprocessing program portion of C81 had not been converted as yet for usage on CDC CYBER computer systems. The conversion of this part of the program is presently underway. As soon as the conversion is complete and validated by the Army Structures Laboratory, the NAVAIRDEVCEN will receive a new copy of AGAP80 program source on magnetic tape which will include the postprocessing program GDAP80. It is anticipated that this work will be completed by March 1982.

EIGENVALUE CALCULATION

Several test cases were run in an attempt to check out the rotorcraft stability analysis capability of the program. Throughout all attempts the program would successfully calculate and print out the stability derivatives for both the total aircraft and the rotors. The program would then develop and print out the mass matrix, the damping matrix, and the stiffness matrix. Up to this point all output data correlated with the sample rotorcraft stability analysis case in section 6.8 of reference 1. But, when the controls-fixed roots and transfer function denominator were printed out, it was noted that that output data had to be incorrect. For example, the printout would one time show the following 12 complex roots of the rotorcraft characteristic equation:

Root #	Real	Imag
1	.10000E+13	0.
2	.10000E+13	0.
3	.10000E+13	65536.
4	.10000E+13	65536.
5	.10000E+13	65536.
6	.10000E+13	65536.
7	.10000E+13	65536.
8	.10000E+13	65536.
9	.10000E+13	65536.
10	.10000E+13	65536.
11	.10000E+13	65536.
12	.10000E+13	65536.

and the program would stop printing at that point. That is, it would not go on to print out the remaining parts of the stability analysis, namely, the controls-fixed mode shapes, transfer function data, and frequency response data.

Another run of the same case would produce different results. An example of different results is the following 4 complex roots of the rotorcraft characteristic equation:

Root #	Real	Imag.
1	.10000E+13	0.
2	.10000E+13	0.
3	.10000E+13	.15749E-03
4	.10000E+13	518.96

and then the program would continue printing out extraneous controls-fixed mode shape data, transfer function data, and frequency response data to correspond with these 4 strange roots.

There have been several discussions about this problem with personnel at the Army Structures Laboratory and the Applied Technology Laboratory, Ft. Eustis, VA. This problem is still under investigation and is believed to be associated with the conversion of the code for usage on CDC CYBER computer systems. The two subroutines, ALLMAT and ALLVEC, which the stability analysis uses to compute eigenvalues and eigenvectors have had some cards changed as a result of the conversion. It is expected that, with the second conversion of AGAP80 that is currently underway by the Army Structures Laboratory to include the postprocessing program GDAP80, this problem will be resolved.

COST OF PROGRAM OPERATION

The cost of running this program on the CDC CYBER 175/CDC 6600 computer system at NAVAIRDEVCEN has been of interest. With the limited number of cases that have been run thus far throughout this checkout and validation stage, a cost breakdown for trim analysis, stability analysis, and maneuver simulation is presented in the following sections.

TRIMMED FLIGHT ANALYSIS

The cost of running a trimmed flight analysis is directly related to the number of iterations required to converge to a trimmed flight condition. Two factors determine this number of iterations. The program is set up to accept inputs of allowable errors in the force and moment summations (XIT(15) through XIT(21) of the Iteration Logic Group). Normally, the smaller the allowable errors, the larger the number of iterations required for trim.

Also, the initial settings of the control positions, the Euler angles, the rotor flapping angles and rotor thrust inputs have a direct bearing on how many iterations are required to converge to a trim. These are all inputs in the Flight Constants Group (XFC(5) through XFC(20)). The closer these values are to the final trim value, the faster the analysis will converge on trim. In a parameter sweep, the previous trim point is the starting condition for finding the next trim point. So, for example, in a speed sweep, a change of 20 or 30 knots is the most that should normally be used between 40 and 150 knots. Outside of this range, the maximum change should not exceed 10 knots.

A typical trimmed flight analysis cost about \$25 to \$30 and used about 20 to 25 cp seconds execution time. Whereas, a parameter sweep of five airspeeds for trim cost about \$95 to \$100 and used about 75 to 80 cp seconds of execution time.

The program includes the option for two basic types of rotor analyses for trim: Quasi-Static (QS) and Time-Variant (TV). The cost data discussed above is for a QS rotor analysis trim. A Time-Variant (TV) trim is much more expensive and is generally used to simulate an aeroelastic rotor when blade load data are desired. The Quasi-Static (QS) rotor analysis is best suited to rotor systems where the dominant blade motions are at 1/rev and where, for most performance and flying qualities investigations, other flapping frequencies can be neglected. The major limitation of the Quasi-Static analysis is that only the static and 1/rev component of the blades response are calculated. Consequently, accurate computation of blade loads is not possible. For a more detailed explanation of the two types of rotor analyses, the reader is referred to Volume I, section 2.2 of reference 3.

Two identical trimmed flight analyses were run with the only difference being the requirement for one to be a QS trim followed by a TV trim of the main rotor. The data below gives an indication of the difference in cost to perform these two analyses.

Case #	Type of Trim	Execution Time ~ CP Seconds	Cost
10	QS + TV	68.427	\$86.10
11	QS only	21.555	\$27.72

The Time-Variant portion of a Quasi-Static trim followed by a Time-Variant trim is in essence a time-history of XIT(6) rotor revolutions with the fuselage and control positions locked. (In this case XIT(6) = 7 rotor revolutions). For each rotor which is Time-Variant, the additional run time for the Time-Variant trim after the Quasi-Static trim will be about the same as the time for a maneuver of XIT(6) rotor revolutions.

ROTORCRAFT STABILITY ANALYSIS

A rotorcraft stability analysis can be performed following a Quasi-Static trim. With the eigenvalue calculation problem that was discussed in an earlier section, only preliminary cost data for this operation can be discussed. At least five cases were run in an attempt to checkout this analysis operation. In all cases the program stopped short of computing the correct eigenvalues. Some cases computed incorrect eigenvalues and used those in further computations, while other cases caused the program to terminate after calculating and printing out the extraneous roots.

Even with these problems in the rotorcraft stability analysis, all indications lead to the assumption that, if the analysis were completed with correct computations of the eigenvalues, the cost of operations would be approximately the same. The following data gives an indication of anticipated cost of operation of the trim followed by rotorcraft stability analysis.

Case#	Type Of Analysis	Execution Time CP Seconds	Cost	Comments
6	TRIM+STAB.ANAL.(1)	42.067	$52.77	Program terminated before analysis completed
7	TRIM+STAB.ANAL.(1)	41.951	$52.58	Program terminated before analysis completed
8	TRIM+STAB.ANAL.(1)	43.363	$54.34	Analysis completed with incorrect eigenvalues
9	TRIM+STAB.ANAL.(2)	23.203	$29.94	Analysis completed with incorrect eigenvalues
12	TRIM+STAB.ANAL.(2)	26.585	$33.93	Program terminated before analysis completed
15	TRIM+STAB.ANAL.(2) (3 Case Parameter Sweep)	59.487	$74.04	Program terminated before last analysis completed

(1) Coupled fuselage (one 6x6 matrix) in stability analysis matrix; no rotor flapping degrees of freedom

(2) Uncoupled fuselage (two 3x3 matrices) in stability analysis matrix; both rotor flapping degrees of freedom

MANEUVER SIMULATION

The amount of computer execution time required to perform a maneuver simulation is dependent on two factors: 1) the time increment (Δt) between the calculation of maneuver time points; and 2) the total length of maneuver time. These two factors can be lumped into one by the simple fact that:

$$\text{number of maneuver time points} = \frac{\text{total length of maneuver time}}{(\Delta t)\ \text{time increment between maneuver time points}}$$

Therefore, the cost of running a maneuver simulation is directly related to the number of maneuver time points.

Section 4.28 of reference 1 discusses some of the contraints placed on the size of Δt. These requirements generally apply to Time-Variant maneuvers.

The sample maneuver simulation case discussed earlier was a trim followed by maneuver, both of which used a Quasi-Static rotor analysis. The maneuver begins at time t = 0.0, ends at time t = 7.5 seconds, and the time increment (Δt) between the calculation of maneuver time points is .02 seconds.

A Δt equal to .02 seconds was found to be both adequate and necessary for this aircraft with this rotor system with a rotational speed of 324.1 RPM, using the Quasi-Static rotor analysis for maneuver. A Δt of .02 seconds corresponds with a maneuver time point calculation every 38.9 degrees of main rotor azimuth. It was found that when Δt was input as .05 seconds (every 97.2 degrees of rotor azimuth) the numerical integration technique went unstable. A Δt of .02 seconds or less (approximately 30 degrees or rotor azimuth or less) is recommended for Quasi-Static maneuvers. To insure stability of the numerical technique during a Time-Variant maneuver, the azimuth increment should always be less than or equal to 15 degrees.

The following data illustrates the cost of performing maneuver simulations with this program. It must be mentioned that the cost figures are for a digital listing of the maneuver time point data and do not represent any postprocessing of maneuver data, such as time history plots, harmonic analysis, etc.

Case#	Type of Analysis	Maneuver Time Lgth. ~Seconds	Δt Seconds	No. of Maneuver Points	Execution Time ~ CP Sec	Total Cost	Cost Time Pt
1	TV TRIM+MAN.SIM.	.201	.00386	52	73.742	$ 93.82	$1.80
2	QS TRIM+MAN.SIM.	8.224	.01543	533	455.266	$552.60	$1.04
3	QS TRIM+MAN.SIM.	.300	.05	6	27.068	$ 34.72	$5.79
4	QS TRIM+MAN.SIM.	2.500	.02	125	125.954	$154.28	$1.23
5	QS TRIM+MAN.SIM.	6.900	.02	345	320.090	$389.15	$1.13
16	QS TRIM+MAN.SIM.	7.500	.02	375	383.842	$479.49	$1.28

The cost/time point for case 3 is ambiguous since it cost $27.89 of the $34.72 total cost to perform the trimmed flight analysis. Therefore, it cost $6.83 for 6 maneuver time points, $1.14/time point. It must be kept in mind that in each of the above cases, the total cost includes the cost to perform the trimmed flight analysis.

From the data presented it can be seen that it costs approximately $1.15/time point to perform a maneuver simulation. Therefore, a maneuver of 5 to 10 seconds in length consisting of 250 to 500 time points is going to cost between $275 and $575 to run.

CONCLUSIONS AND RECOMMENDATIONS

1. The Rotorcraft Flight Simulation Program C81 provides the NAVAIRDEVCEN with an analytical tool necessary to evaluate the flying qualities, performance and aircraft loads of existing and future helicopters.

2. The program in its present form here at NAVAIRDEVCEN (with the eigenvalue calculation problem and inability to perform postprocessing operations) has a limited usability. Trims and maneuvers can be calculated; total aircraft and rotor partial derivatives can be calculated. The limitations are that characteristic equation roots and transfer functions have to be computed in another program and time-history plots of the maneuver data must be hand plotted.

3. The parameter sweep operation works as advertised.

4. Due to the method of billing for computer execution time here at NAVAIRDEVCEN, the cost of running this program is higher than that which most other user facilities experience. Maneuver simulation is an operational capability that is an important asset to this program. It also is expensive to run. It was shown that a typical maneuver cost approximately $1.15/time point and, at this rate, it is not unusual for a single maneuver simulation to cost about $500.

5. It is recommended that the second CDC conversion of the AGAP80 version of C81 (with postprocessing capabilities included) be installed, checked out and validated here at NAVAIRDEVCEN as soon as the conversion is completed.

6. The time-history plotting operation is a highly desirable and valuable asset of C81 that can be used extensively in conjunction with maneuver simulation.

7. The eigenvalue calculation portion of the rotorcraft stability analysis must be made operational. The problem is still under investigation.

8. After the second CDC conversion is implemented on the CDC CYBER 175/CDC 6600 computer system at NAVAIRDEVCEN, the program can be made available for center-wide usage by other helicopter technology disciplines, i.e., structural loads analysts, performance analysts, and control system analysts.

9. Future Navy helicopter designs can be modeled and their flying qualities, flight loads, and performance can be analytically studied with this program when its full capabilities are brought to fruition at this center.

REFERENCES

1. Van Gassbeek, J. R., ROTORCRAFT FLIGHT SIMULATION COMPUTER PROGRAM C81 WITH DATAMAP INTERFACE, Volume I - User's Manual, Bell Helicopter Textron, USAAVRADCOM-TR-80-D-38A, Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia, October 1981.

2. Etkin, Bernard, DYNAMICS OF FLIGHT, New York, N.Y., John, Wiley and Sons, Inc., 1959.

3. McLarty, T. T., et al., ROTORCRAFT FLIGHT SIMULATION WITH COUPLED ROTOR AEROELASTIC STABILITY ANALYSIS, Volumes I - III, Bell Helicopter Textron, USAAMRDL Technical Reports 76-41A, 76-41B, and 76-41C, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, May 1977, AD A042464 (TR 76-41A only).

4. Philbrick, R. D., and Eubanks, A. L., OPERATIONAL LOADS SURVEY - DATA MANAGEMENT SYSTEM, Volumes I and II, USARTL TR 78-52A, -52B, Applied Technology Laboratory, U.S. Army Research and Technology Laboratories, Fort Eustis, Virginia, 1979.

APPENDIX A

SAMPLE INPUT DATA DECK FOR AH-1G HELICOPTER

```
PLEASE RETURN TO B.J. GAJKOWSKI, FLIGHT DYNAMICS, CODE 6053, EXT. 2221  00000100
 2   5                                                                  00000200
   0042201 AH-1G + ULS ROTOR SIMULATION    AGAP80 USER'S MANUAL CASE    00000300
SAMPLE TRIM + MANEUVER -- LONG, LAT + PEDAL DOUBLETS AT VH   (DAT3)     00000400
        LEVEL FLIGHT AT 2900' HP, 27 DEG C   8319 LB   AFT CG           00000500
          OLS PROGRAM LOGIC GROUP                                       00000600
    0    2    0  -20    5    9    0    0    0    0    2    1    0    0  00000700
   -1   -1    1    1    0    0    0    0    0    0    0    0    0    0  00000800
    0    0    0    0    0    0    0    0    0    0    0    0    0    0  00000900
    0    1    5    1    2    0    0    0    0    0    1    0    0    0  00001000
    0    0    0    0    0    0    0    0    0    0    0    0    0    0  00001100
    0    1    1    1    1    0    8    0    0    0    0    0    0    0  00001200
    0    0    3    0    0    0    0    0    0    0    0    0    0    0  00001300
          MODEL 209 M/R AIRFOIL DATA TABLE                            AG00001400
SUPER 540 EXTCDSUPER 540 EXTCD11391175 947                              00001500
        0.0    0.3000 0.5000 0.6000 0.6500 0.7000 0.7500 0.8000 0.8500  00001600
        0.9000 1.0000                                                   00001700
-180.00 0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0     00001800
        0.0    0.0                                                      00001900
-172.00 0.7800 0.7800 0.7800 0.7800 0.7800 0.7800 0.7800 0.7800 0.7800  00002000
        0.7800 0.7800                                                   00002100
-161.00 0.6200 0.6200 0.6200 0.6200 0.6200 0.6200 0.6200 0.6200 0.6200  00002200
        0.6200 0.6200                                                   00002300
-147.00 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000  00002400
        1.0000 1.0000                                                   00002500
-129.00 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000  00002600
        1.0000 1.0000                                                   00002700
 -49.00-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800  00002800
       -1.1800-1.1800                                                   00002900
 -39.00-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800  00003000
       -1.1800-1.1800                                                   00003100
 -21.00-0.8000-0.8100-0.8500-0.8500-0.8500-0.8500-0.7150-0.6800-0.6640  00003200
       -0.6400-0.6410                                                   00003300
 -18.00-0.8580-0.8580-0.8820-0.8700-0.8700-0.8640-0.7540-0.7220-0.6980  00003400
       -0.6700-0.6680                                                   00003500
 -14.00-1.1700-1.1700-0.9280-0.8710-0.8720-0.8530-0.8410-0.8010-0.7670  00003600
       -0.7280-0.7280                                                   00003700
 -12.00-1.2200-1.2200-0.9350-0.8670-0.8670-0.8390-0.8400-0.8180-0.7780  00003800
       -0.7400-0.7370                                                   00003900
 -11.00-1.1800-1.1800-0.9340-0.8620-0.8600-0.8290-0.8320-0.8120-0.7770  00004000
       -0.7400-0.7260                                                   00004100
 -10.00-1.0700-1.0700-0.9300-0.8530-0.8540-0.8150-0.8200-0.8030-0.7700  00004200
       -0.7340-0.7050                                                   00004300
  -9.00-0.9680-0.9680-0.9200-0.8380-0.8400-0.8050-0.8010-0.7810-0.7520  00004400
       -0.7180-0.6720                                                   00004500
  -8.00-0.8600-0.8600-0.8900-0.8130-0.8190-0.7780-0.7800-0.7530-0.7300  00004600
       -0.6900-0.6320                                                   00004700
  -7.00-0.7530-0.7530-0.8300-0.7840-0.7850-0.7540-0.7420-0.7200-0.7040  00004800
       -0.6520-0.5810                                                   00004900
  -6.00-0.6450-0.6450-0.7100-0.7450-0.7220-0.7210-0.6790-0.6720-0.6680  00005000
       -0.6010-0.5200                                                   00005100
  -4.00-0.4300-0.4300-0.4740-0.5240-0.5560-0.5890-0.5650-0.5600-0.5200  00005200
       -0.4500-0.3600                                                   00005300
  -2.00-0.2150-0.2150-0.2370-0.2620-0.2780-0.2980-0.3120-0.3180-0.2600  00005400
       -0.2250-0.1800                                                   00005500
   0.0  0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0     00005600
        0.0    0.0                                                      00005700
   2.00 0.2150 0.2150 0.2370 0.2620 0.2780 0.2980 0.3120 0.3180 0.2600  00005800
        0.2250 0.1800                                                   00005900
   4.00 0.4300 0.4300 0.4740 0.5240 0.5560 0.5890 0.5650 0.5600 0.5200  00006000
```

```
        0.4500 0.3600                                                  00006100
   6.00 0.6450 0.6450 0.7100 0.7450 0.7220 0.7210 0.6790 0.6720 0.6680  00006200
        0.6010 0.5200                                                  00006300
   7.00 0.7530 0.7530 0.8300 0.7840 0.7850 0.7540 0.7420 0.7200 0.7040  00006400
        0.6520 0.6810                                                  00006500
   8.00 0.8600 0.8600 0.8900 0.8130 0.8190 0.7780 0.7800 0.7530 0.7300  00006600
        0.6900 0.6320                                                  00006700
   9.00 0.9680 0.9680 0.9200 0.8300 0.8400 0.8060 0.8010 0.7810 0.7520  00006800
        0.7180 0.6720                                                  00006900
  10.00 1.0750 1.0750 0.9300 0.8530 0.8540 0.8150 0.8200 0.8030 0.7700  00007000
        0.7340 0.7050                                                  00007100
  11.00 1.1840 1.1840 0.9340 0.8620 0.8600 0.8290 0.8320 0.8120 0.7770  00007200
        0.7400 0.7260                                                  00007300
  12.00 1.2200 1.2200 0.9350 0.8670 0.8670 0.8300 0.8400 0.8180 0.7790  00007400
        0.7400 0.7370                                                  00007500
  14.00 1.1720 1.1720 0.9280 0.8710 0.8780 0.8530 0.8410 0.8010 0.7670  00007600
        0.7280 0.7280                                                  00007700
  18.00 0.8580 0.8580 0.8820 0.8700 0.8700 0.8640 0.7540 0.7220 0.6980  00007800
        0.6700 0.6650                                                  00007900
  21.00 0.8000 0.8100 0.8500 0.8500 0.8500 0.8500 0.7150 0.6800 0.6640  00008000
        0.6400 0.6410                                                  00008100
  39.00 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800  00008200
        1.1800 1.1800                                                  00008300
  49.00 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800  00008400
        1.1800 1.1800                                                  00008500
 129.00-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000  00008600
       -1.0000-1.0000                                                  00008700
 147.00-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000  00008800
       -1.0000-1.0000                                                  00008900
 161.00-0.6200-0.6200-0.6200-0.6200-0.6200-0.6200-0.6200-0.6200-0.6200  00009000
       -0.6200-0.6200                                                  00009100
 172.50-0.7800-0.7800-0.7800-0.7800-0.7800-0.7800-0.7800-0.7800-0.7800  00009200
       -0.7800-0.7800                                                  00009300
 180.00 0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0     00009400
        0.0    0.0                                                     00009500
        0.0    0.3000 0.5000 0.6000 0.6500 0.7000 0.7500 0.8000 0.8500  00009600
        0.9000 1.0000                                                  00009700
-180.000.022000.022000.022000.022000.022000.022000.022000.022000.02200  00009800
        0.022000.02200                                                 00009900
-175.000.062000.062000.062000.062000.062000.062000.062000.062000.06200  00010000
        0.062000.06200                                                 00010100
-170.000.132000.132000.132000.132000.132000.132000.132000.132000.13200  00010200
        0.132000.13200                                                 00010300
-165.000.242000.242000.242000.242000.242000.242000.242000.242000.24200  00010400
        0.242000.24200                                                 00010500
-160.000.302000.302000.302000.302000.302000.302000.302000.302000.30200  00010600
        0.302000.30200                                                 00010700
-140.001.042001.042001.042001.042001.042001.042001.042001.042001.04200  00010800
        1.042001.04200                                                 00010900
-120.001.652001.652001.652001.652001.652001.652001.652001.652001.65200  00011000
        1.652001.65200                                                 00011100
-110.001.852001.852001.852001.852001.852001.852001.852001.852001.85200  00011200
        1.852001.85200                                                 00011300
-100.002.002002.002002.002002.002002.002002.002002.002002.002002.00200  00011400
        2.002002.00200                                                 00011500
 -90.002.022002.022002.022002.002002.002002.002002.002002.002002.00200  00011600
        2.002002.00200                                                 00011700
 -80.001.962001.962001.962001.962001.962001.962001.962001.962001.96200  00011800
        1.962001.96200                                                 00011900
 -70.001.842001.842001.842001.842001.842001.842001.842001.842001.84200  00012000
```

```
         1.842001.84200                                                   00012100
  -60.001.662001.662001.662001.662001.662001.662001.662001.662001.66200   00012200
         1.662001.66200                                                   00012300
  -50.001.392001.392001.392001.392001.392001.392001.392001.392001.39200   00012400
         1.392001.39200                                                   00012500
  -30.000.600000.600000.600000.600000.600000.600000.600000.600000.60000   00012600
         0.600000.60000                                                   00012700
  -28.000.540000.540000.563000.578000.578000.581000.581000.581000.58100   00012800
         0.581000.58100                                                   00012900
  -26.000.480000.480000.522000.545000.545000.547000.558000.558000.55800   00013000
         0.558000.55800                                                   00013100
  -24.000.420000.420000.469000.500000.502000.512000.526000.526000.52600   00013200
         0.526000.52600                                                   00013300
  -22.000.358000.358000.409000.448000.461000.472000.489000.491000.49100   00013400
         0.491000.49100                                                   00013500
  -20.000.299000.299000.351000.396000.414000.431000.451000.453000.45300   00013600
         0.453000.45300                                                   00013700
  -18.000.240000.240000.300000.345000.370000.386000.407000.414000.41900   00013800
         0.419000.41900                                                   00013900
  -16.000.191000.191000.253000.300000.326000.341000.358000.367000.38100   00014000
         0.389000.38900                                                   00014100
  -15.000.167000.167000.232000.275000.303000.318000.333000.342000.36500   00014200
         0.372000.37200                                                   00014300
  -13.500.135000.135000.202000.244000.271000.283000.299000.309000.33900   00014400
         0.350000.35100                                                   00014500
  -12.500.100500.100500.175000.220000.249000.261000.274000.285000.32100   00014600
         0.335000.33600                                                   00014700
  -11.500.046000.046000.142000.188000.226000.238000.251000.261000.30200   00014800
         0.319000.32100                                                   00014900
  -10.500.026000.026000.110000.158000.195000.212000.229000.240000.28700   00015000
         0.302000.30500                                                   00015100
   -9.500.017500.017500.078000.127000.164000.188000.204000.218000.26900   00015200
         0.287000.29100                                                   00015300
   -8.500.012500.012500.049000.096000.133000.162000.180000.195000.25000   00015400
         0.269000.27300                                                   00015500
   -7.500.010200.010200.027400.066000.102000.132000.155000.171000.23000   00015600
         0.250000.25700                                                   00015700
   -6.500.009200.009200.012400.039000.071000.102000.127000.146000.21000   00015800
         0.230000.23900                                                   00015900
   -5.500.008500.008500.010000.022300.041500.071500.098500.120000.18700   00016000
         0.211000.22000                                                   00016100
   -4.500.008000.008000.009200.013400.020000.043000.070000.100000.16600   00016200
         0.190000.19800                                                   00016300
   -3.500.007900.007900.008600.008900.012800.026000.045000.070000.14100   00016400
         0.166000.17600                                                   00016500
   -2.500.007400.007400.007800.007800.009300.016500.027000.042000.11000   00016600
         0.140000.15000                                                   00016700
   -1.500.007100.007100.007100.007000.007300.009800.016500.026500.07000   00016800
         0.105000.12000                                                   00016900
   -0.500.006800.006800.006800.006700.006500.007200.008900.016800.05000   00017000
         0.072000.09500                                                   00017100
    0.0 0.006800.006800.006700.006600.006500.006800.007400.015000.04500   00017200
         0.069000.09300                                                   00017300
    0.500.006800.006800.006800.006700.006500.007200.008900.016800.05000   00017400
         0.072000.09500                                                   00017500
    1.500.007100.007100.007100.007000.007300.009800.016500.026500.07000   00017600
         0.105000.12000                                                   00017700
    2.500.007400.007400.007800.007800.009300.016500.027000.042000.11000   00017800
         0.140000.15000                                                   00017900
    3.500.007900.007900.008600.008900.012800.026000.045000.070000.14100   00018000
```

```
      0.166000.17600                                                    00018100
 4.500.008000.008000.009200.013400.020000.043000.070000.100000.16600   00018200
      0.190000.19800                                                    00018300
 5.500.008500.008500.010000.022300.041500.071500.098500.120000.18700   00018400
      0.211000.22000                                                    00018500
 6.500.009200.009200.012400.039000.071000.102000.127000.146000.21000   00018600
      0.230000.23900                                                    00018700
 7.500.010200.010200.027400.066000.102000.132000.155000.171000.23000   00018800
      0.250000.25700                                                    00018900
 8.500.012500.012500.049000.096000.133000.162000.180000.195000.25000   00019000
      0.269000.27300                                                    00019100
 9.500.017500.017500.078000.127000.164000.188000.204000.218000.26900   00019200
      0.287000.29100                                                    00019300
10.500.026000.026000.110000.158000.195000.212000.229000.240000.28700   00019400
      0.302000.30600                                                    00019500
11.500.046000.046000.142000.188000.226000.238000.251000.261000.30200   00019600
      0.319000.32100                                                    00019700
12.500.100500.100500.175000.220000.249000.261000.274000.285000.32100   00019800
      0.335000.33600                                                    00019900
13.500.135000.135000.202000.244000.271000.283000.299000.309000.33900   00020000
      0.350000.35100                                                    00020100
15.000.167000.167000.232000.275000.303000.318000.333000.342000.36500   00020200
      0.372000.37200                                                    00020300
16.000.191000.191000.253000.300000.326000.341000.358000.367000.38100   00020400
      0.389000.38900                                                    00020500
18.000.240000.240000.300000.345000.370000.386000.407000.414000.41900   00020600
      0.419000.41900                                                    00020700
20.000.299000.299000.351000.396000.414000.431000.451000.453000.45300   00020800
      0.453000.45300                                                    00020900
22.000.358000.358000.409000.448000.461000.472000.489000.491000.49100   00021000
      0.491000.49100                                                    00021100
24.000.420000.420000.469000.500000.502000.512000.526000.526000.52600   00021200
      0.526000.52600                                                    00021300
26.000.480000.480000.522000.545000.545000.547000.558000.558000.55800   00021400
      0.558000.55800                                                    00021500
28.000.540000.540000.563000.578000.578000.581000.581000.581000.58100   00021600
      0.581000.58100                                                    00021700
30.000.600000.600000.600000.600000.600000.600000.600000.600000.60000   00021800
      0.600000.60000                                                    00021900
50.001.392001.392001.392001.392001.392001.392001.392001.392001.39200   00022000
      1.392001.39200                                                    00022100
60.001.662001.662001.662001.662001.662001.662001.662001.662001.66200   00022200
      1.662001.66200                                                    00022300
70.001.842001.842001.842001.842001.842001.842001.842001.842001.84200   00022400
      1.842001.84200                                                    00022500
80.001.962001.962001.962001.962001.962001.962001.962001.962001.96200   00022600
      1.962001.96200                                                    00022700
90.002.022002.022002.022002.002002.002002.002002.002002.002002.00200   00022800
      2.002002.00200                                                    00022900
100.002.002002.002002.002002.002002.002002.002002.002002.002002.00200  00023000
      2.002002.00200                                                    00023100
110.001.852001.852001.852001.852001.852001.852001.852001.852001.85200  00023200
      1.852001.85200                                                    00023300
120.001.652001.652001.652001.652001.652001.652001.652001.652001.65200  00023400
      1.652001.65200                                                    00023500
140.001.042001.042001.042001.042001.042001.042001.042001.042001.04200  00023600
      1.042001.04200                                                    00023700
160.000.302000.302000.302000.302000.302000.302000.302000.302000.30200  00023800
      0.302000.30200                                                    00023900
165.000.242000.242000.242000.242000.242000.242000.242000.242000.24200  00024000
```

```
       0.242000.24200                                                 00024100
 170.000.132000.132000.132000.132000.132000.132000.132000.132000.13200  00024200
       0.132000.13200                                                 00024300
 175.000.062000.062000.062000.062000.062000.062000.062000.062000.06200  00024400
       0.062000.06200                                                 00024500
 180.000.022000.022000.022000.022000.022000.022000.022000.022000.02200  00024600
       0.022000.02200                                                 00024700
       0.2000 0.3000 0.4000 0.5000 0.6000 0.7000 0.7500 0.8000 0.9000  00024800
-180.000.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0      00024900
-170.000.400000.400000.400000.400000.400000.400000.400000.400000.40000  00025000
-165.000.300000.300000.300000.300000.300000.300000.300000.300000.30000  00025100
-160.000.300000.300000.300000.300000.300000.300000.300000.300000.30000  00025200
-135.000.500000.500000.500000.500000.500000.500000.500000.500000.50000  00025300
 -90.000.500000.500000.500000.500000.500000.500000.500000.500000.50000  00025400
 -30.000.174000.184000.196000.214000.235000.250000.264000.277000.29800  00025500
 -23.000.112000.118000.128000.144000.157000.171000.183000.206000.23200  00025600
 -16.000.073000.078000.086000.097000.108000.117000.137000.176000.20000  00025700
 -15.000.054000.065000.073000.084000.097000.111000.133000.173000.19500  00025800
 -14.000.0    0.027000.064000.068000.086000.103000.127000.167000.18900  00025900
 -13.000.0    0.001500.025000.050000.074000.093000.122000.163000.18400  00026000
 -12.000.0    0.0    0.002000.030000.060000.083000.116000.157000.17600  00026100
 -11.000.0    0.0    -.003000.014000.046000.074000.108000.149000.17000  00026200
 -10.000.0    0.0    -.002000.002000.032000.065000.100000.142000.16300  00026300
  -9.000.0    0.0    0.0    -.003000.016000.054000.089000.132000.15400  00026400
  -8.000.0    0.0    0.0    -.004000.005000.041000.082000.123000.14500  00026500
  -7.000.0    0.0    0.0    0.0    -.004000.027500.072000.112500.13600  00026600
  -6.000.0    0.0    0.0    0.0    -.003000.016000.062000.100000.12500  00026700
  -4.000.0    0.0    0.0    0.0    0.0    0.005000.040000.076000.10200  00026800
  -3.000.0    0.0    0.0    0.0    0.0    -.003000.026000.066500.08700  00026900
  -2.000.0    0.0    0.0    0.0    0.0    0.0    0.013000.053000.07000  00027000
  -1.000.0    0.0    0.0    0.0    0.0    0.0    0.003500.033000.04600  00027100
   0.0 0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0      00027200
   1.000.0    0.0    0.0    0.0    0.0    0.0    -.00400-.03300-.04500  00027300
   2.000.0    0.0    0.0    0.0    0.0    0.0    -.01300-.05300-.07000  00027400
   3.000.0    0.0    0.0    0.0    0.0    0.00250-.02600-.06700-.08700  00027500
   4.000.0    0.0    0.0    0.0    0.0    -.00500-.04000-.07600-.10200  00027600
   6.000.0    0.0    0.0    0.0    0.00300-.01600-.06300-.10000-.12500  00027700
   7.000.0    0.0    0.0    0.0    0.00400-.02800-.07200-.11300-.13600  00027800
   8.000.0    0.0    0.0    0.00400-.00500-.04100-.08200-.12300-.14500  00027900
   9.000.0    0.0    0.0    0.00300-.01600-.05400-.08900-.13200-.15400  00028000
  10.000.0    0.0    0.00150-.00200-.03200-.06500-.10000-.14200-.16300  00028100
  11.000.0    0.0    0.00300-.01400-.04600-.07400-.10800-.14900-.17000  00028200
  12.000.0    0.0    -.00200-.03000-.06000-.08300-.11600-.15700-.17600  00028300
  13.000.0    -.00200-.02500-.05000-.07400-.09300-.12200-.16300-.18400  00028400
  14.000.0    -.02700-.05400-.06800-.08600-.10300-.12700-.16700-.18900  00028500
  15.00-.05400-.06500-.07300-.08400-.09700-.11100-.13300-.17300-.19500  00028600
  16.00-.07300-.07800-.08600-.09700-.10800-.11700-.13700-.17600-.20000  00028700
  23.00-.11200-.11800-.12800-.14400-.15700-.17100-.18300-.20600-.23200  00028800
  30.00-.17400-.18400-.19600-.21400-.23500-.25000-.26400-.27700-.29800  00028900
  90.00-.50000-.50000-.50000-.50000-.50000-.50000-.50000-.50000-.50000  00029000
 135.00-.50000-.50000-.50000-.50000-.50000-.50000-.50000-.50000-.50000  00029100
 160.00-.30000-.30000-.30000-.30000-.30000-.30000-.30000-.30000-.30000  00029200
 165.00-.30000-.30000-.30000-.30000-.30000-.30000-.30000-.30000-.30000  00029300
 170.00-.40000-.40000-.40000-.40000-.40000-.40000-.40000-.40000-.40000  00029400
 180.000.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0      00029500
          NACA 0015 AS PROVIDED BY PAI  (03-19-77)                    00029600
      NACA 0015                  7411281 2 2                          00029700
       0.     .2     .4     .5     .6     .8     1.0                  00029800
-180.0 0.0    0.0    0.0    0.0    0.0    0.0    0.0                  00029900
-170.0 0.200000.200000.200000.200000.200000.200000.20000              00030000
```

```
-160.0 0.620000.620000.620000.620000.620000.620000.62000          00030100
-150.0 0.800000.800000.800000.800000.800000.800000.80000          00030200
-130.0 0.800000.800000.800000.800000.800000.800000.80000          00030300
-50.0  -0.9800-0.9800-0.9800-0.9800-0.9800-0.9800-0.9800          00030400
-30.0  -0.8700-0.8700-0.8700-0.8700-0.8700-0.8700-0.8700          00030500
-20.0  -0.9000-0.9000-0.9000-0.9000-0.9000-0.9000-0.9000          00030600
-17.0  -1.4400-1.4400-1.2500-0.9750-0.8820-0.7800-0.5300          00030700
-16.0  -1.4700-1.4700-1.2700-1.0000-0.8800-0.7400-0.4100          00030800
-15.0  -1.4800-1.4800-1.2900-1.0300-0.8800-0.7000-0.2900          00030900
-14.0  -1.4500-1.4500-1.3000-1.0900-0.9350-0.7400-0.2900          00031000
-13.0  -1.3600-1.3600-1.2900-1.1400-0.9600-0.7600-0.2850          00031100
-12.0  -1.2500-1.2500-1.2500-1.1500-0.9800-0.7100-0.2750          00031200
-11.0  -1.1500-1.1500-1.1600-1.1500-1.0100-0.6800-0.2650          00031300
-10.0  -1.0500-1.0500-1.0700-1.1000-1.0100-0.6450-0.2400          00031400
-9.0   -0.9450-0.9450-0.9700-1.0400-1.0100-0.6100-0.2150          00031500
-8.0   -0.8400-0.8400-0.8700-0.9200-0.9600-0.5550-0.1900          00031600
-7.0   -0.7350-0.7350-0.7630-0.8150-0.9100-0.5000-0.1650          00031700
-6.0   -0.6300-0.6300-0.6550-0.7100-0.7700-0.4300-0.1400          00031800
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0              00031900
6.0    0.630000.630000.655000.710000.770000.430000.14000          00032000
7.0    0.735000.735000.763000.815000.910000.500000.16500          00032100
8.0    0.840000.840000.870000.920000.960000.555000.19000          00032200
9.0    0.945000.945000.970001.040001.010000.610000.21500          00032300
10.0   1.050001.050001.070001.100001.010000.645000.24000          00032400
11.0   1.150001.150001.160001.150001.010000.680000.26500          00032500
12.0   1.250001.250001.250001.150000.980000.710000.27500          00032600
13.0   1.360001.360001.290001.140000.960000.760000.28500          00032700
14.0   1.450001.450001.300001.090000.935000.740000.29000          00032800
15.0   1.480001.480001.290001.030000.880000.700000.29000          00032900
16.0   1.470001.470001.270001.000000.880000.740000.41000          00033000
17.0   1.440001.440001.250000.975000.882000.780000.53000          00033100
20.0   0.900000.900000.900000.900000.900000.900000.90000          00033200
30.0   0.870000.870000.870000.870000.870000.870000.87000          00033300
50.0   0.980000.980000.980000.980000.980000.980000.98000          00033400
130.0  -0.8000-0.8000-0.8000-0.8000-0.8000-0.8000-0.8000          00033500
150.0  -0.8000-0.8000-0.8000-0.8000-0.8000-0.8000-0.8000          00033600
160.0  -0.6200-0.6200-0.6200-0.6200-0.6200-0.6200-0.6200          00033700
170.0  -0.8000-0.8000-0.8000-0.8000-0.8000-0.8000-0.8000          00033800
180.0  0.0    0.0    0.0    0.0    0.0    0.0    0.0              00033900
        .0     .2     .3     .4     .5     .6     .7    .75    .8     00034000
        .85    .9    1.0                                          00034100
-180.0 0.034300.034300.034300.034300.034300.034300.034300.036300.05560  00034200
       0.090600.126000.12600                                      00034300
-179.0 0.034500.034500.034500.034500.034500.034500.035600.044300.07060  00034400
       0.108000.143000.14300                                      00034500
-178.0 0.034800.034800.034800.034800.034800.034800.037700.053600.09060  00034600
       0.126000.160000.16000                                      00034700
-177.0 0.035100.035100.035100.035100.035100.035100.041100.064100.10800  00034800
       0.143000.177000.17700                                      00034900
-176.0 0.035600.035600.035600.035600.035600.036000.048600.074600.12600  00035000
       0.161000.193000.19300                                      00035100
-175.0 0.036500.036500.036500.036500.036500.038000.061800.095600.14600  00035200
       0.179000.210000.21000                                      00035300
-174.0 0.037600.037600.037600.037600.037700.041300.082600.117000.16400  00035400
       0.196000.226000.22600                                      00035500
-173.0 0.038800.038800.038800.038800.040000.049700.106000.138000.18300  00035600
       0.214000.243000.24300                                      00035700
-172.0 0.040100.040100.040100.040100.042800.065600.128000.159000.20200  00035800
       0.232000.260000.26000                                      00035900
-171.0 0.041600.041600.041600.041900.049600.091600.151000.179000.22100  00036000
```

```
       0.249000.276000.27600                                             00036100
-170.0 0.043600.043600.043600.049800.075600.118000.173000.200000.24000   00036200
       0.267000.293000.29300                                             00036300
-169.0 0.048100.048800.049600.064600.104000.143000.195000.221000.25800   00036400
       0.285000.310000.31000                                             00036500
-168.0 0.053100.053800.058100.083100.133000.170000.216000.241000.27700   00036600
       0.303000.328000.32800                                             00036700
-167.0 0.059600.060800.064800.105000.161000.194000.239000.262000.29600   00036800
       0.321000.343000.34300                                             00036900
-166.0 0.080600.087400.098100.133000.190000.220000.261000.283000.31400   00037000
       0.338000.360000.36000                                             00037100
-165.0 0.115000.120000.132000.166000.219000.245000.283000.304000.33300   00037200
       0.358000.376000.37600                                             00037300
-164.0 0.146000.158000.169000.201000.246000.271000.306000.325000.35200   00037400
       0.374000.393000.39300                                             00037500
-160.0 0.328000.330000.336000.348000.360000.373000.394000.406000.42600   00037600
       0.442000.458000.45800                                             00037700
-130.0 1.250001.250001.250001.250001.250001.250001.250001.250001.25000   00037800
       1.250001.250001.25000                                             00037900
-90.0  1.770001.770001.770001.770001.770001.770001.770001.770001.77000   00038000
       1.770001.770001.77000                                             00038100
-50.0  1.150001.150001.150001.150001.150001.150001.150001.150001.15000   00038200
       1.150001.150001.15000                                             00038300
-20.0  0.300000.304000.310000.322000.334000.347000.362000.380000.40000   00038400
       0.416000.432000.43200                                             00038500
-18.0  0.126000.138000.149000.180000.259000.279000.309000.326000.35100   00038600
       0.382000.400000.40000                                             00038700
-17.0  0.095100.100000.112000.145000.222000.246000.280000.299000.32600   00038800
       0.365000.383000.38300                                             00038900
-16.0  0.060600.067400.078100.112000.195000.220000.257000.278000.30700   00039000
       0.348000.367000.36700                                             00039100
-15.0  0.049700.051300.056600.084000.166000.195000.235000.257000.28800   00039200
       0.330000.350000.35000                                             00039300
-14.0  0.041300.042200.045300.062000.137000.169000.213000.236000.27000   00039400
       0.312000.334000.33400                                             00039500
-13.0  0.034900.035800.036800.043500.109000.145000.190000.215000.25100   00039600
       0.295000.317000.31700                                             00039700
-12.0  0.029000.029000.029000.036000.079200.118000.169000.195000.23200   00039800
       0.277000.300000.30000                                             00039900
-11.0  0.026000.026000.026000.026300.051600.092700.147000.174000.21500   00040000
       0.259000.284000.28400                                             00040100
-10.0  0.023400.023400.023400.023400.032800.066700.125000.153000.19500   00040200
       0.241000.267000.26700                                             00040300
-9.0   0.020800.020800.020800.020800.024000.040700.102000.133000.17600   00040400
       0.223000.250000.25000                                             00040500
-8.0   0.018900.018900.018900.018900.020000.032000.080200.112000.15700   00040600
       0.206000.234000.23400                                             00040700
-7.0   0.017200.017200.017200.017200.017200.021100.052200.091000.13000   00040800
       0.188000.217000.21700                                             00040900
-6.0   0.015600.015600.015600.015600.015600.016900.036400.070000.12000   00041000
       0.170000.200000.20000                                             00041100
-5.0   0.014100.014100.014100.014100.014100.014100.030100.049000.10000   00041200
       0.153000.184000.18400                                             00041300
-4.0   0.013000.013000.013000.013000.013000.013000.020400.042700.08250   00041400
       0.136000.167000.16700                                             00041500
-3.0   0.012300.012300.012300.012300.012300.012300.015900.036400.06500   00041600
       0.117000.151000.15100                                             00041700
-2.0   0.012000.012000.012000.012000.012000.012000.013200.024300.04500   00041800
       0.100000.134000.13400                                             00041900
-1.0   0.011500.011500.011500.011500.011500.011500.011500.015000.03900   00042000
```

```
         0.082500.117000.11700                                             00042100
0.0      0.011300.011300.011300.011300.011300.011300.011300.012500.03300   00042200
         0.065000.100000.10000                                             00042300
1.0      0.011500.011500.011500.011500.011500.011500.011500.015000.03900   00042400
         0.082500.117000.11700                                             00042500
2.0      0.012000.012000.012000.012000.012000.012000.013200.024300.04500   00042600
         0.100000.134000.13400                                             00042700
3.0      0.012300.012300.012300.012300.012300.012300.015900.036400.06500   00042800
         0.117000.151000.15100                                             00042900
4.0      0.013000.013000.013000.013000.013000.013000.020400.042700.08250   00043000
         0.136000.167000.16700                                             00043100
5.0      0.014100.014100.014100.014100.014100.014100.030100.049000.10000   00043200
         0.153000.184000.18400                                             00043300
6.0      0.015600.015600.015600.015600.015600.016900.036400.070000.12000   00043400
         0.170000.200000.20000                                             00043500
7.0      0.017200.017200.017200.017200.017200.021100.052200.091000.13000   00043600
         0.188000.217000.21700                                             00043700
8.0      0.018900.018900.018900.018900.020000.032000.058200.112000.15700   00043800
         0.206000.234000.23400                                             00043900
9.0      0.020800.020800.020800.020800.024000.040700.102000.133000.17600   00044000
         0.223000.250000.25000                                             00044100
10.0     0.023400.023400.023400.023400.032800.066700.125000.153000.19500   00044200
         0.241000.267000.26700                                             00044300
11.0     0.026000.026000.026000.026300.051600.092700.147000.174000.21500   00044400
         0.259000.284000.28400                                             00044500
12.0     0.029000.029000.029000.036000.079200.118000.169000.195000.23200   00044600
         0.277000.300000.30000                                             00044700
13.0     0.034900.035800.036800.043500.109000.145000.190000.215000.25100   00044800
         0.296000.317000.31700                                             00044900
14.0     0.041300.042200.045300.062000.137000.169000.213000.236000.27000   00045000
         0.312000.334000.33400                                             00045100
15.0     0.049700.051300.056600.084000.166000.195000.235000.257000.28800   00045200
         0.330000.350000.35000                                             00045300
16.0     0.060600.067400.078100.112000.195000.220000.257000.278000.30700   00045400
         0.348000.367000.36700                                             00045500
17.0     0.095100.100000.112000.145000.222000.246000.280000.299000.32600   00045600
         0.365000.383000.38300                                             00045700
18.0     0.126000.138000.149000.180000.259000.279000.309000.326000.35100   00045800
         0.382000.400000.40000                                             00045900
20.0     0.300000.304000.310000.322000.334000.347000.368000.380000.40000   00046000
         0.416000.432000.43200                                             00046100
50.0     1.150001.150001.150001.150001.150001.150001.150001.150001.15000   00046200
         1.150001.150001.15000                                             00046300
90.0     1.770001.770001.770001.770001.770001.770001.770001.770001.77000   00046400
         1.770001.770001.77000                                             00046500
130.0    1.250001.250001.250001.250001.250001.250001.250001.250001.25000   00046600
         1.250001.250001.25000                                             00046700
160.0    0.326000.330000.336000.348000.360000.373000.394000.406000.42600   00046800
         0.442000.458000.45800                                             00046900
164.0    0.146000.158000.169000.201000.246000.271000.306000.325000.35200   00047000
         0.374000.393000.39300                                             00047100
165.0    0.115000.120000.132000.166000.219000.245000.283000.304000.33300   00047200
         0.366000.376000.37600                                             00047300
166.0    0.080600.087400.098100.133000.190000.220000.261000.283000.31400   00047400
         0.338000.360000.36000                                             00047500
167.0    0.059600.060800.064800.105000.161000.194000.239000.262000.29600   00047600
         0.321000.343000.34300                                             00047700
168.0    0.053100.053800.056100.083100.133000.170000.216000.241000.27700   00047800
         0.303000.326000.32600                                             00047900
169.0    0.048100.048800.049600.064600.104000.143000.195000.221000.25800   00048000
```

```
          0.285000.310000.31000                                                  00048100
170.0     0.043600.043600.043600.049800.075600.118000.173000.200000.24000        00048200
          0.267000.293000.29300                                                  00048300
171.0     0.041600.041600.041600.041900.049600.091600.151000.179000.22100        00048400
          0.249000.276000.27600                                                  00048500
172.0     0.040100.040100.040100.040100.042800.065600.120000.159000.20200        00048600
          0.232000.260000.26000                                                  00048700
173.0     0.038800.038800.038800.038800.040000.049700.106000.138000.18300        00048800
          0.214000.243000.24300                                                  00048900
174.0     0.037600.037600.037600.037600.037700.041300.062600.117000.16400        00049000
          0.196000.226000.22600                                                  00049100
175.0     0.036500.036500.036500.036500.036500.038000.061800.095600.14600        00049200
          0.179000.210000.21000                                                  00049300
176.0     0.035600.035600.035600.035600.035600.036000.048600.074600.12600        00049400
          0.161000.193000.19300                                                  00049500
177.0     0.035100.035100.035100.035100.035100.035100.041100.064100.10800        00049600
          0.143000.177000.17700                                                  00049700
178.0     0.034800.034800.034800.034800.034800.034800.037700.053600.09060        00049800
          0.126000.160000.16000                                                  00049900
179.0     0.034500.034500.034500.034500.034500.034500.035600.044300.07060        00050000
          0.108000.143000.14300                                                  00050100
180.0     0.034300.034300.034300.034300.034300.034300.034300.036300.05560        00050200
          0.090600.126000.12600                                                  00050300
          0.0     1.0                                                            00050400
-180.0                                                                           00050500
 180.0                                                                           00050600
            AH-1G MAIN ROTOR GROUP 209 ROTOR WITH OLS INSTR., NO PYLON           00050700
2.0         4.50        101.0       22.0        0.0         -10.0       12.0     00050800
200.0       0.0         152.76      475.6       1385.08     .0491       0.0      00050900
1.0         0.0         18099.      0.0         1.0         0.0         3.4      00051000
2.75        0.0         0.0         .13         0.0         0.0         0.0      00051100
0.0         0.0         -9.067      14.1        0.0         0.0         -0.682   00051200
0.0         0.0         0.0         0.0         2.0         -0.759      100.55   00051300
0.0         0.0         0.0         0.0         0.0         0.0         0.0      00051400
5.4         0.0         0.0         0.0         0.0         0.0         0.0      00051500
6.0         20.575      37.5        52.8        66.0        81.5        92.4     00051600
103.0       118.8       132.0       145.2       155.8       171.6       184.8    00051700
198.0       212.3       224.4       238.1       250.8       264.0                00051800
0.0         0.0         0.0         0.0         0.0         0.0         -0.28125 00051900
-0.28125    -0.28125    -0.28125    -0.28125    -0.28125    -0.28125    -0.28125 00052000
-0.28125    -0.28125    -0.28125    -0.28125    -0.28125    -0.28125    0.0      00052100
14.0        19.6        8.2         27.0        27.0        27.0        28.625   00052200
28.625      28.625      28.625      28.625      28.625      28.625      28.625   00052300
28.625      28.625      28.625      28.625      28.625      28.625               00052400
            540279  26 SEG OLS MR  PRECONE AND UNDERSLING HSOFT = -17.2          00052500
    5.3702      5.7138      6.1672      4.8217      0.9620      0.7750    0.8580 00052600
    0.8360      0.8690      0.7620      0.7260      0.8750      1.0980    1.0620 00052700
    1.0390      1.2600      1.1860      1.2660      1.1890      1.1600    0.0    00052800
0.000100000.059028130.089800000.013079740.002400000.001700000.00170000           00052900
0.001700000.001800000.001400000.001300000.001400000.002400000.00240000           00053000
0.001400000.001200000.001300000.001500000.001800000.002700000.0                  00053100
0.069000000.114854890.118969870.226381700.118300000.118900000.14690000           00053200
0.145300000.155300000.135700000.130500000.122000000.146000000.12900000           00053300
0.115900000.125500000.104500000.122600000.116100000.139900000.0                  00053400
    0.0         0.0         0.0         0.0         0.0         0.0       0.0    00053500
    0.0         0.0         0.0         0.0         0.0         0.0       0.0    00053600
    0.0         0.0         0.0         0.0         0.0         0.0       0.0    00053700
    0.0         0.0533      3.6100      1.5292      0.9000      1.3900    1.7700 00053800
    1.7100      2.3850      1.4500      1.3400      0.8500      0.5708   -0.5600 00053900
    0.0100     -1.0170     -1.8700     -1.1290     -1.9700     -0.4300    0.0    00054000
```

-1.	1.000027	3.102101	0.000	-4.78	5783.71		1	-100054100
22.34	0.0	324.00	15.00	2.612248	-0.000615		1	-100054200
63.2346	5.0431	-0.0661	-0.0025	0.053497	0.000179		1	-100054300
-0.000001	0.000181	-0.11166	0.0000	-84.5548	16.4948	1	-1	00054400
0.022734	0.000181	-0.00915	10.7704	-81.9700	-18.4011	1	-1	00054500
0.078096	0.000172	-0.04525	10.6965	-75.9978	-100.2014	1	-1	00054600
0.142384	0.000141	-0.10118	18.6203	-69.9713	-78.4327	1	-1	00054700
0.200446	0.000082	-0.13366	36.0195	-63.7284	-36.0390	1	-1	00054800
0.250641	0.000029	-0.16444	48.6448	-57.0024	-14.3409	1	-1	00054900
0.309331	-0.000041	-0.20535	62.6420	-50.3783	-7.2001	1	-1	00055000
0.350624	-0.000090	-0.23791	70.8787	-45.5232	2.2013	1	-1	00055100
0.390743	-0.000160	-0.27199	76.1566	-41.3468	27.2729	1	-1	00055200
0.450470	-0.000257	-0.32259	78.4713	-36.9640	63.0444	1	-1	00055300
0.500340	-0.000344	-0.36833	77.6669	-31.8884	104.7575	1	-1	00055400
0.550166	-0.000436	-0.41214	72.2795	-28.4888	137.3630	1	-1	00055500
0.590156	-0.000515	-0.44544	66.2597	-26.1889	165.3552	1	-1	00055600
0.649793	-0.000631	-0.48431	57.4585	-23.1217	190.1138	1	-1	00055700
0.699654	-0.000727	-0.51028	51.2418	-20.0790	216.7308	1	-1	00055800
0.749566	-0.000819	-0.52917	46.9985	-17.0037	223.8854	1	-1	00055900
0.803685	-0.000917	-0.54184	43.3100	-13.5433	218.5189	1	-1	00056000
0.849522	-0.000996	-0.54781	33.4903	-9.9614	174.3218	1	-1	00056100
0.901486	-0.001080	-0.55048	23.9515	-6.3769	123.1197	1	-1	00056200
0.949750	-0.001149	-0.55078	12.4606	-3.0319	60.3629	1	-1	00056300
1.000000	-0.001212	-0.55071	2.3620	-0.5999	9.7422	1	-1	00056400
						15	324.	1-00056500
-1.	1.599443	2.510692	0.020	5251.70	-1296.81		2	-100056600
-1342.10	0.0	324.00	15.00	-2.723861	0.235062		2	-100056700
0.0825	-0.8280	48.7245	1.3001	-0.044664	-0.196211		2	-100056800
0.000000	-0.198724	0.00091	0.	118480.	3.	2	-1	00056900
-0.015490	-0.198288	-0.00596	-1331.	115642.	26.	2	-1	00057000
-0.068209	-0.192127	2.75899	-4255.	107964.	1127.	2	-1	00057100
-0.113171	-0.165107	3.04418	-7187.	97854.	721.	2	-1	00057200
-0.146630	-0.119578	3.17903	-9922.	88256.	534.	2	-1	00057300
-0.164771	-0.073806	3.26606	-11555.	79730.	455.	2	-1	00057400
-0.168256	-0.011751	3.35636	-11833.	70298.	428.	2	-1	00057500
-0.161672	0.036395	3.41793	-11297.	63969.	390.	2	-1	00057600
-0.150265	0.086024	3.46774	-10433.	58003.	358.	2	-1	00057700
-0.127438	0.164085	3.51943	-8883.	49397.	319.	2	-1	00057800
-0.104608	0.232488	3.54963	-7506.	42478.	288.	2	-1	00057900
-0.079476	0.303362	3.56914	-6116.	35829.	273.	2	-1	00058000
-0.057949	0.361824	3.57854	-5038.	30703.	263.	2	-1	00058100
-0.024688	0.451099	3.58243	-3628.	23497.	258.	2	-1	00058200
0.003881	0.527312	3.58168	-2643.	17972.	248.	2	-1	00058300
0.032833	0.604731	3.57976	-1835.	12967.	238.	2	-1	00058400
0.064471	0.689616	3.58036	-1160.	8270.	220.	2	-1	00058500
0.091373	0.761988	3.58214	-698.	5019.	179.	2	-1	00058600
0.121690	0.844250	3.58437	-343.	2239.	131.	2	-1	00058700
0.149339	0.920621	3.58205	-125.1167	630.3089	70.5592	2	-1	00058800
0.177566	1.000000	3.58116	-15.8482	14.2813	16.3724	2	-1	00058900
						15	324.	2-00059000
-1.	2.357852	13.776395	0.040	-5591.61	17334.48		3	-100059100
-44839.62	0.0	324.00	15.00	-7.102327	-0.370118		3	-100059200
-1.2861	-2.5932	-30.6560	-0.2790	-0.058877	0.207827		3	-100059300
0.000000	0.211587	0.00438	-0.	-175567.	207.	3	-1	00059400
-0.001116	0.210947	0.02700	-8809.	-172326.	207.	3	-1	00059500
-0.126842	0.201986	70.52215	30877.	-168611.	34301.	3	-1	00059600
-0.306581	0.166938	79.72098	35776.	-149901.	29179.	3	-1	00059700
-0.453686	0.107524	83.20216	29450.	-138456.	26511.	3	-1	00059800
-0.567151	0.052699	86.18941	22025.	-127607.	24384.	3	-1	00059900
-0.671766	-0.012673	89.82363	14900.	-114613.	23390.	3	-1	00060000

-0.717203	-0.057063	92.48225	10669.	-105400.	21940.	3	-1	00060100
-0.734011	-0.097726	95.11710	7740.	-96290.	20560.	3	-1	00060200
-0.716802	-0.155169	98.83376	4367.	-82737.	18686.	3	-1	00060300
-0.663156	-0.200104	102.00225	2131.	-71591.	16877.	3	-1	00060400
-0.575178	-0.242496	105.23556	1250.	-60564.	15111.	3	-1	00060500
-0.478763	-0.274489	107.88665	1150.	-51912.	13748.	3	-1	00060600
-0.308192	-0.321134	110.81715	644.	-38763.	12171.	3	-1	00060700
-0.148534	-0.359715	113.12753	-248.	-30483.	10456.	3	-1	00060800
0.026124	-0.398618	115.13466	-1582.	-22145.	9079.	3	-1	00060900
0.222620	-0.441106	116.92508	-3376.	-14390.	7621.	3	-1	00061000
0.392122	-0.477486	118.16934	-3335.	-8856.	6109.	3	-1	00061100
0.578391	-0.519821	119.22220	-3269.	-4136.	4550.	3	-1	00061200
0.734178	-0.561017	119.79440	-2071.	-1284.	2769.	3	-1	00061300
0.880010	-0.605455	120.00000	-444.5682	-73.8982	922.0508	3	-1	00061400
						15	324.	3-00061500
-1.	2.856066	2.216849	0.023	-1108.53	-24890.88		4	-10061600
7626.20	0.0	324.00	15.00	-3.579679	-0.107229		4	-10061700
0.4818	-2.1624	-6.8485	-0.1947	-0.116089	0.040737		4	-10061800
-0.000000	0.041947	-0.01147	0.	-57826.	-113.	4	-1	00061900
-0.061625	0.041737	-0.05314	4550.	-57153.	-18.	4	-1	00062000
-0.150378	0.038896	-14.04663	9059.	-56043.	-5566.	4	-1	00062100
-0.241351	0.027291	-15.58658	16924.	-51193.	-5580.	4	-1	00062200
-0.321459	0.006743	-16.29219	18850.	-47080.	-5667.	4	-1	00062300
-0.384093	-0.011743	-16.90146	17879.	-43320.	-5411.	4	-1	00062400
-0.441870	-0.032465	-17.65942	16792.	-38797.	-5236.	4	-1	00062500
-0.478057	-0.046285	-18.23680	16134.	-35554.	-5027.	4	-1	00062600
-0.493048	-0.059041	-18.83677	15389.	-32395.	-4844.	4	-1	00062700
-0.505989	-0.076187	-19.75764	14210.	-27680.	-4646.	4	-1	00062800
-0.498199	-0.088491	-20.65234	13261.	-23770.	-4398.	4	-1	00062900
-0.469772	-0.098358	-21.59326	12495.	-19916.	-4108.	4	-1	00063000
-0.430084	-0.104232	-22.38507	12081.	-16877.	-3806.	4	-1	00063100
-0.337325	-0.108821	-23.47308	11387.	-12587.	-3368.	4	-1	00063200
-0.226846	-0.108606	-24.32776	10587.	-9330.	-2762.	4	-1	00063300
-0.084327	-0.104588	-25.10138	9685.	-6417.	-2213.	4	-1	00063400
0.105032	-0.096228	-25.80655	8324.	-3780.	-1623.	4	-1	00063500
0.290153	-0.086408	-26.28386	6402.	-2104.	-1123.	4	-1	00063600
0.521666	-0.073002	-26.68456	3896.	-804.	-742.	4	-1	00063700
0.752180	-0.058998	-26.96014	1568.	-167.	-482.	4	-1	00063800
1.000000	-0.043676	-27.07975	105.4116	6.4924	-229.8067	4	-1	00063900
						15	324.	4-00064000
-1.	4.502123	2.691704	0.021	624.58	47758.83		5	-10064100
5657.36	0.0	324.00	15.00	6.492745	0.164532		5	-10064200
-1.2348	2.1936	3.7770	0.0095	0.216222	-0.021749		5	-10064300
-0.000000	-0.023634	-0.00081	0.	89348.	175.	5	-1	00064400
0.115838	-0.023304	0.07330	-8930.	88887.	-4.	5	-1	00064500
0.275498	-0.019508	-1.92482	-49701.	87177.	-4538.	5	-1	00064600
0.398518	-0.010215	-2.26706	-74151.	83913.	2364.	5	-1	00064700
0.475628	0.009518	-1.69418	-66384.	81304.	5667.	5	-1	00064800
0.489870	0.018818	-0.96478	-50901.	78374.	6954.	5	-1	00064900
0.410933	0.013431	0.12927	-36891.	73469.	7317.	5	-1	00065000
0.304066	0.001564	1.06417	-29167.	69289.	7714.	5	-1	00065100
0.170332	-0.014054	2.14283	-22539.	64859.	7933.	5	-1	00065200
-0.062345	-0.040506	3.95150	-13304.	57874.	7987.	5	-1	00065300
-0.265170	-0.061323	5.71914	-6210.	51810.	7555.	5	-1	00065400
-0.452866	-0.077058	7.50551	840.	45768.	6943.	5	-1	00065500
-0.576081	-0.083442	8.89113	6571.	40957.	6235.	5	-1	00065600
-0.689592	-0.079418	10.60377	14180.	33773.	5346.	5	-1	00065700
-0.698268	-0.061149	11.77159	18470.	27684.	4593.	5	-1	00065800
-0.612644	-0.028065	12.69168	20770.	21642.	4151.	5	-1	00065900
-0.405939	0.024136	13.42686	19836.	15191.	3844.	5	-1	00066000

-0.147121	0.079432	13.95736	16276.	10065.	3732.	5	-1		00066100
0.215975	0.150671	14.40300	9609.	4986.	3258.	5	-1		00066200
0.592666	0.221053	14.47098	3388.	1590.	2142.	5	-1		00066300
1.000000	0.295952	14.42519	-46.5423	58.7771	644.6338	5	-1		00066400
						15	324.	5-	00066500
1.	1.043365	8.891906	0.020	-18.18	5806.86			1	100066600
12.10	0.0	324.00	15.00	2.319131	-0.055155			1	100066700
85.7206	4.6028	0.0002	-0.0176	0.023977	-0.001165			1	100066800
-0.000000	-0.000000	-0.03270	6702.	0.	-23.	1	1		00066900
0.001811	-0.000497	-0.03437	4030.	-55.	-26.	1	1		00067000
0.046088	-0.001625	-1.77708	2584.	-181.	-100.	1	1		00067100
0.106014	-0.002384	-1.82730	1925.	-239.	-70.	1	1		00067200
0.161318	-0.002920	-1.85368	1418.	-279.	-34.	1	1		00067300
0.210117	-0.003157	-1.88178	1059.3573	-297.1123	-14.3201	1	1		00067400
0.269232	-0.003056	-1.92024	803.0429	-285.9786	-7.7337	1	1		00067500
0.311530	-0.002839	-1.95104	699.6148	-263.2272	8.4068	1	1		00067600
0.362900	-0.002583	-1.98388	620.2547	-238.3863	27.8015	1	1		00067700
0.414896	-0.002143	-2.03306	526.3818	-199.3198	64.2759	1	1		00067800
0.466838	-0.001754	-2.07859	463.8959	-166.5974	107.3822	1	1		00067900
0.518895	-0.001351	-2.12280	398.6606	-136.9465	141.5464	1	1		00068000
0.560745	-0.001025	-2.15705	348.5411	-114.9885	171.1462	1	1		00068100
0.623442	-0.000501	-2.19816	285.8363	-85.0319	207.1550	1	1		00068200
0.676167	-0.000022	-2.22634	245.3763	-62.8178	228.7831	1	1		00068300
0.729266	0.000501	-2.24742	217.0266	-41.6348	235.3866	1	1		00068400
0.787177	0.001111	-2.26188	192.9669	-22.8594	230.6481	1	1		00068500
0.836458	0.001656	-2.26906	146.9324	-12.4069	184.5402	1	1		00068600
0.892604	0.002310	-2.27262	101.6482	-4.1641	130.6349	1	1		00068700
0.945082	0.002960	-2.27315	50.9713	-0.5283	63.9925	1	1		00068800
1.000000	0.003671	-2.27313	8.8254	0.0916	10.1278	1	1		00068900
						15	324.	1	00069000
1.	2.270090	10.993640	0.038	-8110.69	8632.22			2	100069100
-37321.28	0.0	324.00	15.00	-9.847487	-1.936770			2	100069200
-2.6732	-3.3482	0.7706	-0.7426	-0.090404	-0.039431			2	100069300
-0.000003	-0.000001	-0.13737	-8787.	-0.	240.	2	1		00069400
-0.004718	-0.016777	-0.11629	-13704.	1913.	248.	2	1		00069500
-0.181664	-0.057286	61.63460	17066.	6310.	28746.	2	1		00069600
-0.402438	-0.099356	69.28320	18879.	8575.	23847.	2	1		00069700
-0.581014	-0.132077	72.16347	10624.	7423.	21324.	2	1		00069800
-0.709190	-0.154331	74.59741	2413.	5912.	19488.	2	1		00069900
-0.810815	-0.169603	77.53023	-3799.	4790.	18657.	2	1		00070000
-0.845794	-0.172568	79.66004	-6554.	4278.	17445.	2	1		00070100
-0.849427	-0.169246	81.74937	-7805.	4007.	16298.	2	1		00070200
-0.809980	-0.155488	84.65669	-8489.	3700.	14744.	2	1		00070300
-0.737610	-0.136551	87.17257	-8445.	3454.	13106.	2	1		00070400
-0.631910	-0.111615	89.57640	-7236.	3329.	11860.	2	1		00070500
-0.522563	-0.087371	91.43720	-5790.	3251.	10792.	2	1		00070600
-0.333192	-0.046809	93.79819	-4189.	2926.	9576.	2	1		00070700
-0.155696	-0.009793	95.53215	-3508.	2474.	8268.	2	1		00070800
0.033694	0.029115	97.03504	-3436.	1888.	7224.	2	1		00070900
0.249470	0.072859	98.37677	-3947.	1150.	6112.	2	1		00071000
0.436683	0.110585	99.31294	-3331.	687.	4919.	2	1		00071100
0.645454	0.153067	100.10684	-2898.	209.	3669.	2	1		00071200
0.825798	0.191148	100.52903	-1754.	-16.	2218.	2	1		00071300
1.000000	0.229485	100.67863	-376.3695	-31.1289	722.9441	2	1		00071400
						15	324.	2	00071500
1.	3.010958	2.209843	0.027	-3091.16	-26826.05			3	100071600
11887.78	0.0	324.00	15.00	-3.696078	-0.700754			3	100071700
-1.4912	-1.7705	-0.1460	-0.3628	-0.044422	-0.014444			3	100071800
0.000000	0.000000	0.00001	-21027.	-0.	9.	3	1		00071900
-0.004592	-0.006153	-0.00296	-8200.	760.	17.	3	1		00072000

```
-0.079958 -0.021178 -14.63207     -5885.      2422.     -8807.  3  1        00072100
-0.176369 -0.039199 -17.01803      2139.      4000.     -8273.  3  1        00072200
-0.265272 -0.055096 -18.04343      5893.      4657.     -8137.  3  1        00072300
-0.337283 -0.067544 -18.92786      6777.      4679.     -7732.  3  1        00072400
-0.409108 -0.079150 -20.02584      7663.      4686.     -7487.  3  1        00072500
-0.450864 -0.085302 -20.85926      8272.      4693.     -7181.  3  1        00072600
-0.484049 -0.089657 -21.71948      8659.      4657.     -6909.  3  1        00072700
-0.515888 -0.092525 -23.02481      9034.      4551.     -6598.  3  1        00072800
-0.523758 -0.091855 -24.27496      9273.      4428.     -6225.  3  1        00072900
-0.509930 -0.086001 -25.57602      9598.      4288.     -5820.  3  1        00073000
-0.480570 -0.078598 -26.66127     10006.      4176.     -5407.  3  1        00073100
-0.399276 -0.061459 -28.14129     10396.      3897.     -4822.  3  1        00073200
-0.293807 -0.041366 -29.29851     10326.      3629.     -4016.  3  1        00073300
-0.151287 -0.015960 -30.34402     10009.      3069.     -3287.  3  1        00073400
 0.043950  0.017036 -31.29839      9054.      2440.     -2493.  3  1        00073500
 0.238572  0.048639 -31.94704      7172.      1766.     -1782.  3  1        00073600
 0.485058  0.087434 -32.49322      4487.       987.     -1209.  3  1        00073700
 0.732714  0.126432 -32.86310      1846.       365.      -766.  3  1        00073800
 1.000000  0.165890 -33.02163   186.5091    25.5150  -334.5708  3  1        00073900
                                                                15 324. 3 00074000
       1.  4.684478  2.807663      0.020   26934.63   51157.01         4 100074100
   -71.12  0.0         324.00      15.00   8.689367   2.981796         4 100074200
  -0.6479    1.8164   -0.2815     0.9836   0.100298   0.061502         4 100074300
 0.000000  0.000000   0.00002     42432.         0.      -113.  4  1        00074400
 0.009644  0.026236  -0.00153     18085.    -10114.      -129.  4  1        00074500
 0.180586  0.088899  -5.68682    -20265.    -33017.      -101.  4  1        00074600
 0.360206  0.149494  -4.70474    -47203.    -51037.      7382.  4  1        00074700
 0.492479  0.189459  -3.43346    -41747.    -54657.     11288.  4  1        00074800
 0.547669  0.208499  -2.01639    -27565.    -53023.     13007.  4  1        00074900
 0.501851  0.203960   0.01154    -15615.    -51181.     13519.  4  1        00075000
 0.407994  0.185943   1.71542     -9552.    -49749.     14098.  4  1        00075100
 0.278868  0.159377   3.64021     -4573.    -47962.     14443.  4  1        00075200
 0.040102  0.108307   6.82427      2344.    -44289.     14612.  4  1        00075300
-0.177325  0.060032   9.95922      7583.    -40388.     14112.  4  1        00075400
-0.385631  0.011325  13.18726     12857.    -35808.     13274.  4  1        00075500
-0.527522 -0.024933  15.76569     17228.    -31660.     12241.  4  1        00075600
-0.669267 -0.070083  19.08319     23023.    -24838.     10852.  4  1        00075700
-0.698113 -0.096122  21.48067     25813.    -19007.      9417.  4  1        00075800
-0.626843 -0.109507  23.48956     26576.    -13417.      8369.  4  1        00075900
-0.426801 -0.109109  25.20590     23828.     -8139.      7395.  4  1        00076000
-0.167066 -0.098308  26.42107     18881.     -4594.      6644.  4  1        00076100
 0.202025 -0.077960  27.44927     10738.     -1865.      5491.  4  1        00076200
 0.585465 -0.054888  27.84136      3624.      -479.      3558.  4  1        00076300
 1.000000 -0.029398  27.91078       -88.       -29.      1142.  4  1        00076400
                                                                15 324. 4 00076500
          AH-1G TAIL ROTOR GROUP      (OLS CORRELATION)                   00076600
2.0       .410      0.0       4.25      8.40      0.0       11.0          00076700
520.67    14.10     118.27    15.081    1.532     .251      0.0           00076800
0.0       0.0       10000.    0.0       0.0       0.0       .541          00076900
1.5       0.0       45.0      .12       0.0       0.0       .2            00077000
0.0       0.0       2.03      2.76      0.0       0.0       0.0           00077100
0.0       0.0       0.0       0.0       .25       0.0       .560          00077200
0.0       0.0       -90.0     0.0       0.0       0.0       0.0           00077300
0.0       0.0       0.0       0.0       0.0       0.0       0.0           00077400
          AH-1G M/R IN GROUP ONE, T/R IN GROUP TWO  (OLS CORRELATION)     00077500
.78       1.11      1.2323    .2964     -2.3074   1.540     .8            00077600
.1084     -.1029    .3846     -.2449    0.0       0.0       0.0           00077700
0.0       0.0       .0971     1.0       0.0       0.2       1.            00077800
0.0       0.0       0.0       0.0       0.0       0.0       0.0           00077900
0.0       0.0       0.0       0.0       0.0       0.003     0.0           00078000
```

```
.75       1.292     1.4916    .1263     -1.7286   .4167     .8                  00078100
.108      -.1907    .8779     -.8683    0.0       0.0       0.0                 00078200
0.0       0.0       .15       2.0       0.0       .2        1.0                 00078300
0.0       0.0       0.0       0.0       0.0       0.0       0.0                 00078400
0.0       0.0       0.0       0.0       0.0       0.0       0.0                 00078500
          RIVD TABLE FOR AGAP80, 3 ADVANCE RATIOS, 2 INFLOW RATIOS              00078600
FLT 35A, SIGMA-PRIME 80.8636                      3  2  6                       00078700
0.2628    0.2925    0.3212                                                      00078800
-0.04     -0.01                                                                 00078900
    0.77379   0.02622  -0.26218  -0.38042   0.99633   0.01980  -0.81307         00079000
              0.30485   0.38995  -0.10281  -0.17137   0.13839  -0.06278         00079100
    0.61389   0.23738   0.09292  -0.37968   0.57576   0.16393  -0.10319         00079200
              0.08568   0.18343  -0.08498  -0.11261   0.05498   0.05440         00079300
    0.60058   0.39385   0.22592  -0.33188   0.43402   0.29951  -0.00228         00079400
              0.05858   0.06431  -0.02701  -0.07879   0.08497   0.05892         00079500
    0.44874   0.36540   0.42816  -0.19800   0.15767   0.19885   0.17773         00079600
              0.10416  -0.08085  -0.01999   0.02123   0.02325  -0.05771         00079700
    0.35882   0.41317   0.52982  -0.20171  -0.03776   0.23021   0.30325         00079800
              0.05324  -0.16479   0.02530   0.03289  -0.04507  -0.03868         00079900
    0.38155   0.42798   0.43293  -0.09690  -0.05857   0.16889   0.28029         00080000
              0.12338  -0.15073  -0.03139  -0.03181  -0.04497  -0.00325         00080100
    0.38974   0.42222   0.44311   0.06953  -0.03851   0.18368   0.19142         00080200
              0.13948  -0.15148  -0.02182  -0.10033  -0.09378  -0.05315         00080300
    0.32385   0.34006   0.41889   0.12340  -0.08341   0.08190   0.25709         00080400
              0.25735  -0.08757  -0.02492  -0.15927  -0.06095  -0.06849         00080500
    0.28084   0.23392   0.32729   0.21395  -0.02779   0.10610   0.17462         00080600
              0.19839  -0.06850  -0.01044  -0.12128  -0.02272  -0.06535         00080700
    0.33570   0.15858   0.46326   0.33009  -0.00041  -0.06961   0.05517         00080800
              0.04448   0.01693  -0.06874  -0.18304  -0.14377  -0.05076         00080900
    0.42492   0.12305   0.44684   0.26823   0.01043  -0.12498   0.01793         00081000
             -0.02880  -0.02050  -0.05752  -0.19838  -0.11327  -0.10193         00081100
    0.53004   0.07423   0.47934   0.17828   0.02348  -0.21107  -0.00543         00081200
             -0.08395  -0.05780  -0.03729  -0.23714  -0.07903  -0.14641         00081300
    0.68228  -0.01705   0.54430   0.13102   0.11311  -0.24751   0.00928         00081400
             -0.16093  -0.04617  -0.05298  -0.17191  -0.03923  -0.11738         00081500
    0.72359  -0.34287   0.75912   0.16628   0.46339  -0.18631  -0.03716         00081600
             -0.43076  -0.07300  -0.18942   0.05314   0.05031  -0.06358         00081700
    0.89626  -0.34546   0.76704   0.14459   0.44433  -0.23219   0.00981         00081800
             -0.41650  -0.00537  -0.15129   0.09435   0.06694  -0.03498         00081900
    1.15493  -0.44141   0.82085   0.04284   0.45166  -0.31628   0.05640         00082000
             -0.33400   0.00285   0.01785  -0.00455   0.18875  -0.15468         00082100
    1.34511  -0.61906   0.71831   0.05109   0.49720  -0.82950   0.10630         00082200
             -0.26103  -0.06343  -0.03308  -0.07860   0.11499  -0.11007         00082300
    1.81312  -1.01754   0.63626  -0.00233   0.48811  -0.14102   0.05144         00082400
             -0.13050  -0.17354  -0.03991  -0.10793   0.03132  -0.00454         00082500
    1.63294  -0.77442   2.33077  -0.51703   0.43330  -0.03266  -0.44917         00082600
              0.07470  -0.11649  -0.10347   0.17125  -0.10258  -0.08125         00082700
    3.19446  -1.07569   5.07106  -1.17876   1.86794  -0.64296  -0.77055         00082800
              0.05105  -1.29574   0.37712  -0.28513   0.21339   0.59558         00082900
    0.77379   0.02622  -0.26218  -0.38042   0.99633   0.01980  -0.21307         00083000
              0.30485   0.38995  -0.10281  -0.17137   0.13839  -0.06278         00083100
    0.61389   0.23738   0.09292  -0.37968   0.57576   0.16393  -0.10319         00083200
              0.08568   0.18343  -0.08498  -0.11261   0.05498   0.05440         00083300
    0.60058   0.39385   0.22592  -0.33188   0.43402   0.29951  -0.00228         00083400
              0.05858   0.06431  -0.02701  -0.07879   0.08497   0.05892         00083500
    0.44874   0.36540   0.42816  -0.19800   0.15767   0.19885   0.17773         00083600
              0.10416  -0.08085  -0.01999   0.02123   0.02325  -0.05771         00083700
    0.35882   0.41317   0.52982  -0.20171  -0.03776   0.23021   0.30325         00083800
              0.05324  -0.16479   0.02530   0.03289  -0.04507  -0.03868         00083900
    0.38155   0.42798   0.43293  -0.09690  -0.05857   0.16889   0.28029         00084000
```

AD-A115 801 NAVAL AIR DEVELOPMENT CENTER WARMINSTER PA AIRCRAFT --ETC F/G 14/2
USER'S GUIDE FOR THE ROTORCRAFT FLIGHT SIMULATION COMPUTER PROG--ETC(U)
MAR 82 B J GAJKOWSKI
UNCLASSIFIED NADC-81290-60 NL

2 OF 2
AD A
115801

END
DATE FILMED
07-82
DTIC

	0.12338	-0.15073	-0.03139	-0.03121	-0.04497	-0.00325	00084100
0.38974	0.42222	0.44311	0.06963	-0.03881	0.18358	0.19142	00084200
	0.13948	-0.15148	-0.02188	-0.10033	-0.09378	-0.05315	00084300
0.32385	0.34006	0.41889	0.12340	-0.08341	0.08190	0.25709	00084400
	0.25735	-0.08757	-0.02492	-0.15927	-0.06095	-0.06849	00084500
0.28084	0.23392	0.32729	0.21396	-0.02779	0.10610	0.17462	00084600
	0.19639	-0.06856	-0.01044	-0.12128	-0.02272	-0.06535	00084700
0.33570	0.15858	0.46386	0.33009	-0.00041	-0.06961	0.05517	00084800
	0.04448	0.01693	-0.06874	-0.18304	-0.14377	-0.05075	00084900
0.42492	0.12305	0.44684	0.26823	0.01043	-0.12498	0.01703	00085000
	-0.02280	-0.02050	-0.05752	-0.19838	-0.11387	-0.10193	00085100
0.53004	0.07423	0.47934	0.17828	0.02348	-0.21107	-0.00643	00085200
	-0.02395	-0.05780	-0.03729	-0.23714	-0.07903	-0.14641	00085300
0.66226	-0.01705	0.54430	0.13102	0.11311	-0.24751	0.00928	00085400
	-0.16093	-0.04617	-0.06298	-0.17191	-0.03923	-0.11738	00085500
0.72369	-0.34287	0.75912	0.16622	0.46330	-0.18631	-0.03716	00085600
	-0.43076	-0.07300	-0.12942	0.05314	0.05031	-0.06358	00085700
0.89626	-0.34546	0.76704	0.14459	0.44433	-0.23219	0.00981	00085800
	-0.41650	-0.00537	-0.15129	0.09436	0.06694	-0.03498	00085900
1.15493	-0.44141	0.82086	0.04284	0.45158	-0.31628	0.05640	00086000
	-0.33400	0.00285	0.01785	-0.00465	0.18875	-0.15468	00086100
1.34511	-0.61906	0.71831	0.05109	0.49720	-0.22950	0.10630	00086200
	-0.28103	-0.06343	-0.03308	-0.07860	0.11499	-0.11007	00086300
1.81312	-1.01754	0.63626	-0.00233	0.48211	-0.14102	0.05144	00086400
	-0.13060	-0.17364	-0.03991	-0.10793	0.03132	-0.00454	00086500
1.63294	-0.77442	2.33077	-0.51703	0.43330	-0.03266	-0.44917	00086600
	0.07470	-0.11649	-0.10347	0.17125	-0.10258	-0.08125	00086700
3.19446	-1.07569	5.07106	-1.17876	1.86794	-0.64296	-0.77065	00086800
	0.05105	-1.29674	0.37712	-0.28513	0.21339	0.59558	00086900
0.70675	0.04946	0.07595	-0.79383	0.47443	0.08515	0.12748	00087000
	-0.19192	0.38547	0.07497	0.02644	0.06961	0.25137	00087100
0.60427	0.10364	0.36617	-0.58380	0.24218	0.12979	0.24894	00087200
	-0.09313	0.16613	0.09641	0.03343	-0.02689	0.08540	00087300
0.51828	0.14384	0.51130	-0.43934	0.03261	0.12897	0.36919	00087400
	0.00325	-0.01996	0.07617	0.06850	-0.05537	-0.04106	00087500
0.49981	0.15417	0.49228	-0.34884	-0.04343	0.06860	0.38835	00087600
	0.10126	-0.05033	0.01746	0.02405	-0.02964	-0.02681	00087700
0.50767	0.16968	0.44377	-0.29135	-0.07836	0.02390	0.38743	00087800
	0.17144	-0.04403	-0.01807	-0.03150	-0.02189	0.00673	00087900
0.52812	0.20066	0.51603	-0.15457	-0.12581	-0.02347	0.46537	00088000
	0.37263	-0.03744	-0.05981	-0.11739	0.06858	0.05068	00088100
0.55290	0.22369	0.43136	-0.14791	-0.13689	-0.03211	0.43621	00088200
	0.35984	-0.02189	-0.05107	-0.14429	0.02623	0.05378	00088300
0.52060	0.14905	0.42236	-0.03770	-0.10078	-0.04656	0.30836	00088400
	0.26444	0.05130	0.05046	-0.11511	-0.00380	-0.04551	00088500
0.43944	-0.03644	0.54764	0.28643	0.02461	0.02463	0.04944	00088600
	0.16447	0.05081	0.08481	-0.15318	-0.07117	-0.08833	00088700
0.43497	-0.07394	0.43017	0.24609	0.01261	-0.00359	0.05141	00088800
	0.11192	0.09361	0.10622	-0.07969	-0.02013	-0.08162	00088900
0.42519	-0.14687	0.39396	0.31405	0.03664	0.00048	-0.03259	00089000
	0.02462	0.12969	0.16170	-0.01883	-0.00016	-0.14096	00089100
0.46281	-0.14889	0.33970	0.31065	0.02366	0.00633	-0.03294	00089200
	0.01048	0.11694	0.14459	-0.00363	0.01766	-0.12900	00089300
0.53959	-0.17603	0.20645	0.30350	0.02228	0.00899	-0.03885	00089400
	-0.03009	0.00647	0.10329	0.02230	0.05189	-0.11128	00089500
0.60143	-0.30729	0.30227	0.31942	0.11769	0.04752	-0.08720	00089600
	-0.14315	0.00952	0.01757	0.09281	0.12752	-0.08395	00089700
0.79075	-0.33081	0.34166	0.27140	0.11146	-0.06280	-0.05950	00089800
	-0.20450	0.03378	-0.00681	0.06929	0.10165	-0.12075	00089900
1.06023	-0.43306	0.45287	0.24999	0.20067	-0.09469	-0.02294	00090000

	-0.23455	-0.02358	-0.08413	-0.02038	0.01160	-0.14691	00000100
1.28637	-0.76415	0.45185	0.16077	0.40718	-0.03198	0.10628	00000200
	-0.18330	-0.12618	-0.19603	-0.13310	-0.10123	-0.07156	00000300
1.81061	-1.16305	0.43733	0.13936	0.50741	-0.01332	0.17082	00000400
	-0.16060	-0.16736	-0.25117	-0.17207	-0.14987	-0.02106	00000500
1.67145	-0.97123	2.33007	-0.62477	0.40128	0.02769	-0.46536	00000600
	0.09605	-0.12176	-0.25743	0.19657	-0.29081	-0.01721	00000700
3.29061	-1.32699	5.18979	-1.41799	1.88932	-0.78145	-0.81998	00000800
	0.04432	-1.36444	0.30869	-0.27626	0.09345	0.70386	00000900
0.70675	0.04046	0.07605	-0.70303	0.47443	0.00515	0.12748	00001000
	-0.19198	0.30547	0.07497	0.00844	0.00951	0.25137	00001100
0.60427	0.10364	0.35617	-0.58300	0.24218	0.12979	0.24094	00001200
	-0.00313	0.10613	0.00641	0.03343	-0.00689	0.00540	00001300
0.51886	0.14304	0.51139	-0.43034	0.03861	0.12807	0.36919	00001400
	0.00305	-0.01985	0.07617	0.00860	-0.05537	-0.04106	00001500
0.40081	0.15417	0.40000	-0.34004	-0.04343	0.06060	0.30835	00001600
	0.10186	-0.06033	0.01745	0.02405	-0.02964	-0.02681	00001700
0.50787	0.10080	0.44377	-0.20135	-0.07835	0.02300	0.38743	00001800
	0.17144	-0.04403	-0.01807	-0.03150	-0.02189	0.00573	00001900
0.52812	0.20066	0.51603	-0.15467	-0.12581	-0.02347	0.46537	00002000
	0.37283	-0.03744	-0.06081	-0.11730	0.06958	0.05468	00002100
0.55290	0.22360	0.43136	-0.14791	-0.13089	-0.03211	0.43621	00002200
	0.36084	-0.02189	-0.05107	-0.14429	0.02623	0.05378	00002300
0.53050	0.14906	0.42236	-0.03770	-0.10078	-0.04656	0.30836	00002400
	0.26444	0.05136	0.05046	-0.11611	-0.00300	-0.04551	00002500
0.43044	-0.03544	0.54764	0.28643	0.02461	0.02463	0.04944	00002600
	0.16447	0.05081	0.08481	-0.15318	-0.07117	-0.08833	00002700
0.43407	-0.07304	0.43017	0.24600	0.01261	-0.00359	0.05141	00002800
	0.11182	0.09361	0.10622	-0.07969	-0.02013	-0.08162	00002900
0.42519	-0.14687	0.30306	0.31405	0.03664	0.00048	-0.03259	00003000
	0.02462	0.12059	0.16170	-0.01883	-0.00016	-0.14096	00003100
0.46281	-0.14829	0.33070	0.31065	0.02366	0.00633	-0.03294	00003200
	0.01048	0.11094	0.14459	-0.00363	0.01766	-0.12900	00003300
0.53959	-0.17603	0.20645	0.30350	0.02228	0.00899	-0.03885	00003400
	-0.03009	0.08647	0.10329	0.02230	0.05189	-0.11128	00003500
0.60143	-0.30729	0.30227	0.31942	0.11769	0.04752	-0.08720	00003600
	-0.14315	0.00952	0.01757	0.09281	0.12758	-0.08395	00003700
0.79075	-0.33081	0.34166	0.27140	0.11146	-0.06280	-0.05950	00003800
	-0.20450	0.03378	-0.00681	0.06989	0.10165	-0.12075	00003900
1.06023	-0.43308	0.45287	0.24990	0.20067	-0.09469	-0.02294	00004000
	-0.23455	-0.02358	-0.08413	-0.02038	0.01160	-0.14691	00004100
1.28637	-0.76415	0.45185	0.16077	0.40718	-0.03198	0.10628	00004200
	-0.18330	-0.12618	-0.19603	-0.13310	-0.10123	-0.07156	00004300
1.81061	-1.16305	0.43733	0.13936	0.50741	-0.01332	0.17082	00004400
	-0.16060	-0.16736	-0.25117	-0.17207	-0.14987	-0.02106	00004500
1.67145	-0.97123	2.33007	-0.62477	0.40128	0.02769	-0.46536	00004600
	0.09605	-0.12176	-0.25743	0.19657	-0.29081	-0.01721	00004700
3.29061	-1.32699	5.18979	-1.41799	1.88932	-0.78145	-0.81998	00004800
	0.04432	-1.36444	0.30869	-0.27626	0.09345	0.70386	00004900
0.66733	0.02692	0.09839	-0.85265	-0.00137	0.02467	0.15728	00005000
	-0.39280	-0.07700	0.00215	0.15526	-0.15382	-0.06747	00005100
0.64857	0.04575	0.25108	-0.73964	-0.04664	-0.01730	0.34076	00005200
	-0.21831	-0.07500	-0.07082	0.21965	-0.02229	-0.00976	00005300
0.56189	-0.01628	0.50162	-0.45704	-0.13107	-0.17265	0.44110	00005400
	0.05883	0.02998	-0.10806	0.12043	0.05757	0.00598	00005500
0.57623	0.01045	0.54200	-0.33224	-0.13080	-0.17096	0.46948	00005600
	0.20328	0.06851	-0.07098	0.04586	0.10350	0.11092	00005700
0.60676	0.04649	0.51133	-0.27976	-0.12138	-0.14750	0.46689	00005800
	0.26180	0.08764	-0.03114	-0.00111	0.10656	0.10598	00005900
0.49834	-0.13099	0.62291	0.00662	-0.07283	-0.23304	0.24542	00006000

	0.20833	0.26932	0.14125	-0.07372	0.00869	0.02702	00096100
0.52556	-0.10483	0.56744	0.01756	-0.07490	-0.20944	0.22431	00096200
	0.19457	0.25875	0.15830	-0.07098	0.00491	-0.00675	00096300
0.51271	-0.14793	0.56398	0.10559	-0.06050	-0.20305	0.12365	00096400
	0.12062	0.29685	0.23950	-0.04530	-0.01429	-0.10652	00096500
0.47343	-0.27511	0.54481	0.20684	0.07026	-0.07098	0.00128	00096600
	0.00841	0.19782	0.19281	0.03986	0.05266	-0.10836	00096700
0.51714	-0.25103	0.49463	0.22255	0.05812	-0.03952	-0.00954	00096800
	0.00799	0.15804	0.16600	0.03155	0.04812	-0.10488	00096900
0.56443	-0.23604	0.44552	0.23744	0.04204	-0.01599	-0.01760	00097000
	0.00486	0.12619	0.14141	0.02781	0.04821	-0.00785	00097100
0.60402	-0.23120	0.39906	0.23965	0.02117	-0.01445	-0.01656	00097200
	0.00254	0.11883	0.13147	0.03020	0.05112	-0.00161	00097300
0.61733	-0.35448	0.36788	0.29458	0.09746	0.07916	-0.08106	00097400
	-0.08030	0.03341	0.05874	0.12011	0.14322	-0.04124	00097500
0.65762	-0.45770	0.28639	0.26813	0.14697	0.13977	-0.02746	00097600
	-0.02015	-0.02365	0.00864	0.04880	0.06815	-0.00795	00097700
0.77171	-0.50364	0.23313	0.27513	0.12476	0.12888	-0.01477	00097800
	-0.01466	-0.02382	0.00072	0.03206	0.04846	-0.00805	00097900
0.95514	-0.59936	0.18602	0.28630	0.11083	0.11198	-0.00304	00098000
	-0.02058	-0.02538	-0.01633	0.01814	0.02608	-0.01047	00098100
1.22426	-0.76334	0.13215	0.31166	0.11801	0.09060	0.01793	00098200
	-0.03988	-0.03390	-0.04176	0.00036	0.00333	-0.01208	00098300
1.74580	-1.18968	0.08468	0.34617	0.21286	0.15438	0.06687	00098400
	-0.00990	-0.11795	-0.14003	-0.08160	-0.10911	0.00591	00098500
1.57376	-0.97061	2.05420	-0.53954	0.12359	0.19782	-0.57776	00098600
	0.25811	-0.05911	-0.18821	0.29318	-0.31025	-0.00864	00098700
3.22066	-1.37892	4.96860	-1.43562	1.67084	-0.64878	-0.91338	00098800
	0.18178	-1.32230	0.41546	-0.19508	0.09218	0.72437	00098900
0.66733	0.02692	0.09839	-0.85265	-0.00137	0.02467	0.15788	00099000
	-0.39280	-0.07700	0.00215	0.15526	-0.15382	-0.06747	00099100
0.64857	0.04575	0.25108	-0.73964	-0.04664	-0.01739	0.34076	00099200
	-0.21831	-0.07500	-0.07082	0.21965	-0.02220	-0.00976	00099300
0.56189	-0.01626	0.50162	-0.45704	-0.13107	-0.17265	0.44110	00099400
	0.06883	0.02998	-0.10806	0.12043	0.05757	0.09598	00099500
0.57623	0.01045	0.54200	-0.33224	-0.13080	-0.17096	0.46948	00099600
	0.20326	0.06851	-0.07098	0.04586	0.10360	0.11092	00099700
0.60676	0.04649	0.51133	-0.27976	-0.12138	-0.14750	0.46689	00099800
	0.26180	0.08764	-0.03114	-0.00111	0.10656	0.10598	00099900
0.49834	-0.13099	0.62291	0.00662	-0.07283	-0.23304	0.24542	00100000
	0.20833	0.26932	0.14125	-0.07372	0.00869	0.02702	00100100
0.52556	-0.10483	0.56744	0.01756	-0.07490	-0.20944	0.22431	00100200
	0.19457	0.25875	0.15830	-0.07098	0.00491	-0.00675	00100300
0.51271	-0.14793	0.56398	0.10559	-0.06050	-0.20305	0.12365	00100400
	0.12062	0.29685	0.23950	-0.04530	-0.01429	-0.10652	00100500
0.47343	-0.27511	0.54481	0.20684	0.07026	-0.07098	0.00128	00100600
	0.00841	0.19782	0.19281	0.03986	0.05266	-0.10836	00100700
0.51714	-0.25103	0.49463	0.22255	0.05812	-0.03952	-0.00954	00100800
	0.00799	0.15804	0.16600	0.03155	0.04812	-0.10488	00100900
0.56443	-0.23604	0.44552	0.23744	0.04204	-0.01599	-0.01760	00101000
	0.00486	0.12619	0.14141	0.02781	0.04821	-0.00785	00101100
0.60402	-0.23120	0.39906	0.23965	0.02117	-0.01445	-0.01656	00101200
	0.00254	0.11883	0.13147	0.03020	0.05112	-0.00161	00101300
0.61733	-0.35448	0.36788	0.29458	0.09746	0.07916	-0.08106	00101400
	-0.08030	0.03341	0.05874	0.12011	0.14322	-0.04124	00101500
0.65762	-0.45770	0.28639	0.26813	0.14697	0.13977	-0.02746	00101600
	-0.02015	-0.02365	0.00864	0.04880	0.06815	-0.00795	00101700
0.77171	-0.50364	0.23313	0.27513	0.12476	0.12888	-0.01477	00101800
	-0.01466	-0.02382	0.00072	0.03206	0.04846	-0.00805	00101900
0.95514	-0.59936	0.18602	0.28630	0.11083	0.11198	-0.00304	00102000

	-0.02058	-0.02536	-0.01633	0.01814	0.02608	-0.01047	00102100
1.22486	-0.76334	0.13215	0.31166	0.11901	0.00060	0.01793	00102200
	-0.03988	-0.03390	-0.04176	0.00036	0.00333	-0.01208	00102300
1.74580	-1.18968	0.06468	0.34617	0.21286	0.15438	0.06687	00102400
	-0.00900	-0.11795	-0.14003	-0.08160	-0.10011	0.00581	00102500
1.57376	-0.97061	2.06480	-0.53054	0.12359	0.19782	-0.57775	00102600
	0.25811	-0.05911	-0.18821	0.28318	-0.31025	-0.00864	00102700
3.22066	-1.37898	4.96860	-1.43562	1.67064	-0.64876	-0.91338	00102800
	0.18178	-1.32230	0.41546	-0.19508	0.00218	0.72437	00102900
	AH-1G FUSELAGE GRP BASE W/INSTRUMENTATION (OLS CORRELATION)						00103000
8319.0	300.0	0.0	71.2	200.6	0.0	68.0	00103100
2904.0	11883.4	10233.5	-526.0	0.0	30.	45.	00103200
0.0	0.0	0.0	0.0	0.0	0.0	-.016492	00103300
-.017946	.32	-.001903	-.0013	.0025	-.000153	-.000306	00103400
5.5	0.0	0.0	0.0	59.0	59.0	.024159	00103500
.03	.032	.0	.0005	.01	.0	-.0003	00103600
-27.0	0.0	0.0	0.0	0.0	0.0	-.001223	00103700
.30646	4.0	.0	.03	-.01	.0	-.0025	00103800
0.0	0.0	0.0	1.6	0.0	-.015	0.0	00103900
2.4	.05	.003	-.022667	.0	-.010832	.0	00104000
.0	.0	.0	-4.7052	-.05	.045	.001	00104100
-.4	-.18	.0	.0	.0	.0	.0	00104200
.0	.0	.0	-3.5	-.05	-.06	.011	00104300
17.57	.0	.0	.014633	.0	-.015293	.0	00104400
	AH-1G WING GROUP						00104500
28.15	180.73	28.53	68.28	14.0	3.24	11.43	00104600
3.96	.98	.588	0.0	0.0	0.0	0.0	00104700
0.0	0.0	0.0	0.0	0.0	0.0	0.0	00104800
0.0	0.0	0.0	0.0	0.0	0.0	0.0	00104900
0.0	0.0	0.0	0.0	0.0	0.0	0.0	00105000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	00105100
.84	1.25	1.2	0.0	0.0	0.0	1.1	00105200
.107	0.0	.0536	0.0	.01	0.0	.000333	00105300
0.0	.2	.27	0.0	0.0	0.0	0.0	00105400
-.002	-.009	.82	0.0	0.0	0.0	0.0	00105500
	AH-1G VERTICAL STABILIZER GROUP (OLS CORRELATION)						00105600
18.87	501.1	0.0	97.18	4.5	90.0	47.59	00105700
1.62	.99	.48	0.0	0.0	0.0	0.0	00105800
0.0	0.0	0.0	0.0	0.0	0.0	0.0	00105900
0.0	0.0	0.0	0.0	0.0	0.0	0.0	00106000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	00106100
.84	1.25	1.20	0.0	0.0	0.0	1.2	00106200
.1	0.0	.05	0.0	.008	0.0	.000137	00106300
.04	.2	.15	0.0	.0332	0.0	0.0	00106400
-.002	-.009	.82	-.005	0.0	0.0	0.0	00106500
	AH-1G R/H HORIZONTAL STABILIZER GROUP (OLS CORRELATION)						00106600
7.57	307.5	18.62	55.66	.697	0.0	16.28	00106700
1.49	.98	.66	0.0	0.0	1.0	0.0	00106800
0.0	0.0	0.0	0.0	0.0	0.0	0.0	00106900
0.0	0.0	0.0	0.0	0.0	0.0	0.0	00107000
	-1.0	-1.0					00107100
.84	1.25	1.2	0.0	0.0	0.0	1.2	00107200
.087	0.0	.0436	0.0	.008	0.0	.0003284	00107300
.04	.20	.15	0.0	.0332	0.0	0.0	00107400
-.002	-.009	.82	.07	0.0	0.0	0.0	00107500
0.0	0.0	0.0	.432858	.220569	0.0	0.0	00107600
0.0	0.0	0.0	0.0	0.0	0.0	0.0	00107700
	AH-1G L/H HORIZONTAL STABILIZER GROUP (OLS CORRELATION)						00107800
7.57	307.5	-18.62	55.66	.697	0.0	16.28	00107900
1.49	.98	.66	0.0	0.0	1.0	0.0	00108000

```
0.0        0.0        0.0        0.0        0.0        0.0        0.0                00108100
0.0        0.0        0.0        0.0        0.0        0.0        0.0                00108200
           -1.0       -1.0       0.0        0.0        0.0        0.0                00108300
.84        1.25       1.2        0.0        0.0        0.0        1.2                00108400
.087       0.0        .0435      0.0        .008       0.0        .0003284           00108500
.04        .20        .15        0.0        .0332      0.0        0.0                00108600
-.002      -.009      .82        .07        0.0        0.0        0.0                00108700
0.0        0.0        0.0        .432858    .220569    0.0        0.0                00108800
0.0        0.0        0.0        0.0        0.0        0.0        0.0                00108900
           AN-16 CONTROLS GROUP  S/N 20391  (OLS CORRELATION)                        00109000
10.0       7.2        19.2                                                           00109100
12.0       -15.6      30.6                                                           00109200
12.0       -11.0      16.87                                                          00109300
6.5        10.0       -28.17     0.0        0.0        0.0        0.0                00109400
            ITERATION LIMITS GROUP                                                   00109500
41.0       10.0       0.5        0.5        3.0        7.0        .3                 00109600
0.2        0.2        1500.      500.       1.0        0.1        2000.              00109700
25.        25.        25.        25.        25.        25.        5.                 00109800
           OLS FLIGHT CONSTANTS GROUP                                                00109900
129.3                            1000.0     -1.2       -3.2       -1.238             00110000
35.0       70.0       55.0       50.0                                                00110100
-2.0       -.5        -1.1       1.0        7450.0     -250.0                        00110200
                      1250.0     6600.0     -1.0       2000.0     27.0               00110300
0.0        0.02       7.5                                                            00110400
    2      0.0        10.0       0.1        0.4        -10.0      0.6                00110500
    2      0.9        10.0       1.0        1.0        0.0        7.5                00110600
    3      1.0        -10.0      1.1        1.4        10.0       1.6                00110700
    3      1.9        -10.0      2.0        2.0        0.0        7.5                00110800
    4      2.0        -5.0       2.1        2.4        5.0        2.6                00110900
/   4      2.9        -5.0       3.0        3.0        0.0        7.5                00111000
 3   5                                                                               00111100
  253   262   244      1         10.0       10.0       10.0                          00111200
  271   200   175      1         10.0       2.0        2.0                           00111300
  234   235   233      1         2.0        2.0        2.0                           00111400
  160   161   162      1         2.0        2.0        2.0                           00111500
  168   169   170      1         5.0        5.0        5.0                           00111600
/ 200   173   230      1         0.2        5.0        100.0                         00111700
```

--EOR--
END OF INFORMATION

FILMED

7-8